CHEMISTRY

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A SCIENCE SERVICE PUBLICATION

Chemistry is a Cultural Subject

➤ CULTURAL HUMANITIES *vs* practical science is an old and tedious argument which received a new and welcome twist at the British Association meeting this summer. Professor John Read, President of the Chemistry Section, made "Specialization and Culture in Chemistry" the subject of his address to the section. He demanded an attitude of mind very congenial to the ideas of the editors of CHEMISTRY: the teaching of the science as its own instrument of culture.

"By presenting chemistry merely as a regimented system of facts, laws, and theories," said Prof. Read, "we sacrifice to a large extent its educative value and abrogate its cultural potentialities. It is easy, for example, to explain the nature and relationships of isomerism in a cut-and-dried manner; but the phenomena acquire a new and vivid interest when related to the boy Liebig standing in the market-place at Darmstadt and watching a pedlar charging toy crackers with silver fulminate; to the almost simultaneous discovery by Wöhler at Stockholm and Liebig in Paris of the isomerism of fulminic and cyanic acids; to the ensuing lifelong friendship between these two palladins of chemistry; to the dramatic scene between Biot and Pasteur at the polarimeter, heralding the birth of stereochemistry; to Kekule's visions of gambolling atoms and the snake biting its tail; and to the coincidence in time of the wider ideas upon which Le Bel and van't Hoff based the fundamental theory of spatial chemistry.

"Chemistry is indeed the most romantic of all branches of science, and in its varigated history, stretching back through unnumbered generations of alchemists into an indefinite past, chemists have a richly humanistic heritage."

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➤ RADIOACTIVE ALGAE *hold the key to man's discovery of the plant's secret. Minute green plants, whose chlorophyll makes use of the energy of sunlight to build complex chemicals out of carbon dioxide and water, are fed radioactive carbon 14. The course of the isotope can be traced by its radioactivity, and the chemist can learn what compounds the plant makes in its synthesis, and under what conditions these compounds form. Oxygen can be traced similarly.*

Solar Energy

by FARRINGTON DANIELS *University of Wisconsin*

An address delivered at the Symposium on Sources of Energy, American Association for the Advancement of Science, Washington, D. C., September, 1948.

➤ FROM THE DAWN of history man has realized the importance of the sun, but only in the present scientific age has he begun to appreciate the vastness of this source of energy and the extraordinarily clever mechanisms by which nature makes efficient use of it. In these times of profligate spending of the world's natural re-

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sources and uncontrolled increase in population it is our task on this 100th anniversary of the founding of the American Association for the Advancement of Science to try to see what lies ahead. Science has pulled us out of many difficulties in the past; and has given us the means for getting ourselves into worse ones. When we have used up our coal and oil, exploited our available land with intense farming and trebled our population can we then call on the sun to give us still more means to satisfy our ever increasing demands for food, fuel and power? *The answer is yes.* But there is a long challenging road of research and development which must be followed first,—and you must not get the idea that we are about to step into a new era of physical and economic abundance. We can't eat sunshine, we can't carry it where we want to use it, and because its temperature at the surface of the earth is too low we can't use it directly in our heat engines.

The earth intercepts a prodigious amount of radiant heat from the sun —about 5×10^{20} large calories or kilocalories per year. Five followed by 20 zeros is too large a figure to register with most of us. Let's try again. When you own an acre of land in the United States, how much of the sun's energy can you expect to get? An acre is roughly a square of land 200 feet on a side, a little less than the length of half a city block, with an area of 40,000 square feet—43,560 square feet per acre to be exact. In most parts of the United States the solar energy averages more than one kilocalorie per square foot per minute, or 500 kilocalories per day. Since each one of the 40,000 square feet in an acre receives 500 kilocalories per day, the whole acre receives 20 million kilocalories per day. Let us see what these figures mean in terms of food, fuel, and power. In the continental United States we now have nearly 144 million people and nearly 2 billion acres of land, giving on the average about 14 acres per person. Fourteen times 20 million kilocalories gives a theoretical average of 200 million kilocalories of sunlight per day per person.

How many calories does each person require on the average? He uses about 3,000 kilocalories to maintain himself with food and vastly more for heat and power. In 1946, 583 million tons of coal were used for heat, light and power by 140 million people in 365 days—an average of 20 pounds per person per day or 110,000 kilocalories. 1.7 billion barrels of oil were used for heat and power including automobiles—an average of 8.5 pounds of petroleum or 40,000 kilocalories per person per day. Nearly four thousand billion cubic feet of natural gas were used in the year, amounting to 75 cubic feet or 19,000 kilocalories per person per day. On the average then, each person had 3000 kilocalories from food and 169,000 from coal, oil and gas—a total of 172,000 kilocalories per day, and we have just shown that this day the sun was supplying his average 14 acres of land with 280,000,000 kilocalories. In other words the sun supplies to the United States 1600 times as much heat energy as is now used.

Utilization of Solar Energy

Of the sun's radiation which hits the earth's atmosphere a considerable portion is reflected and scattered so that about 1 kilocalorie per minute on the average in the temperate zone reaches a square foot of land or water. Some of this is used in evaporating water (which, however, releases this heat again when the water vapor condenses as rain or snow). Most of the visible sunlight, constituting about half of the total radiation reaching the earth can be used for producing carbohydrates and other organic material if it strikes growing plants on land or in the sea, and the rest is available for raising the temperature. The tendency for the earth's temperature to rise, due to solar radiation and by decay of radioactive elements in the earth is nicely counterbalanced by the cooling caused by infra red radiation from the earth corresponding to the earth's temperature.

How can we convert this 20 million kilocalories per acre per day into useful power? If it could be used to operate a modern steam engine or hot gas engine with a normal efficiency of 25% we could obtain electrical power equivalent to 240 kilowatts per acre. But this plan will not work at all because the sun's radiation, falling on the earth's surface, does not create high temperatures unless it is concentrated by excessively expensive mirrors. Just as we must have a difference in level, that is, a waterfall, for a mass of water to produce hydroelectric power, so we must have a difference in temperature for heat to do work. The maximum efficiency obtainable is completely set by the relation $\frac{T_2 - T_1}{T_2}$ where T_2 is the higher absolute temperature and T_1 is the lower.

Even with expensive lenses or reflecting mirrors spread over a large area it is not easy, even on cloudless days, to raise the temperature T_2 high enough to give very efficient conversion of heat into work; and when the sun is obscured with clouds a focusing system is imperative. For house heating, high temperatures are not required and here would seem to lie an opportunity for making more use of the sun. Certainly all scientific principles should be followed in the use of absorbing and reflecting surfaces to obtain maximum heat from the sun in winter and minimum heat in the summer. It may be practical to use reflectors of sufficient area to warm a house on sunny winter days, and certainly heat storage pits of pebble beds or other cheap, quick, heat-exchanging materials should be more thoroughly explored as a means for equalizing temperature—storing the heat of the day to be blown through the house during cool nights and storing the cold of the night air for air conditioning on hot days.

Some attempts have been made to operate vapor engines with low boiling liquids or with water under reduced pressures. These engines are rendered somewhat more practical if they can be located near a large body of cold water to cool the condensers to a low temperature—but still the

low thermodynamic efficiency is a serious handicap.

Windmills are operated, of course, by differences in air pressure caused by solar energy—but although they are very useful in certain areas they are sporadic in operation and do not seem destined to play an important role in meeting the demand for large amounts of power.

Let us consider another approach for the direct conversion of heat into work. Thermocouples made by joining two wires of unlike metals will generate electricity when one junction is hotter than the other. We can produce electricity by placing one junction in the sunlight and one in the shade—but the voltages obtainable are of the order of a few thousandths of a volt per junction and if we use a large number of junctions in series we automatically increase the resistance of our wires to an impractically large value. On a small scale intense radiation from the sun can probably be converted into electricity with an efficiency of a few per cent with equipment that is expensive and short lived. Then again we have photochemical cells which generate electricity when one of the electrodes is exposed to light and the other kept in the dark. Again the voltages are very low and the resistances very high so that the direct generation of thousands of kilowatts of electricity does not appear to be practical.

We must look elsewhere for the conversion of sunlight into useful power. Suppose we use the sunlight to bring about some cheap, efficient photochemical reaction and obtain a product which we can carry around with us and then release the stored energy when and where we please by a second chemical reaction. It would be a good idea to combine carbon dioxide and water to form carbohydrates and other organic materials, and then burn them in the oxygen of the air with the evolution of heat at high temperatures which will be useful for generating power. This sounds like a good idea but there are two serious difficulties—neither carbon dioxide nor water absorb sunlight and without absorption there can be no photochemical reaction. Even if we found a third substance which would absorb the sun's radiant energy and transfer it in some mysterious manner to the carbon dioxide and water, the energy in the units of radiation, called photons, amounts to only about 40 to 60 kilocalories per mole while the energy required to make carbohydrates from carbon dioxide and water is more than 112 kilocalories per mole. Nevertheless, nature solved this problem in a very beautiful manner with chlorophyl and started production of carbohydrates in growing plants soon after the earth cooled off enough to permit the existence of organic material.

Nature did us another good turn by accumulating this carbohydrate material over millions of years, altering its chemical structure to give a greater percentage of combustible carbon, and storing it, so that we can have convenient fossil fuels packaged as solids, liquids, or gases—coal to be shoveled and shipped in chunks, petroleum to be pumped and carried in tanks, and natural gas to flow easily through pipes.

Again nature provided man with

➤ NATURE'S FACTORY *runs on a part-time basis, and its processes are less efficient, Dr. Daniels finds, than was formerly believed.*

a means for getting work done long before he had evolved far enough to invent heat engines. He could obtain mechanical power from the organic material, photo-synthesized by the sun, by feeding it directly to men, horses, water buffalo, or other animals, and then persuading them to do his work for him. The conversion of chemical energy into useful work in this intricate animal process is not limited, as heat engines are limited, by the requirement of a large difference in temperature.

More recently man has tried to compete with nature in using atomic energy under controlled conditions, and Professor Wigner will give you the facts regarding this new source of energy. I am sure however that Professor Wigner will not object if I call attention to the fact that man's much publicized atomic energy is pretty puny in comparison with the sun's energy. An atomic bomb with its equivalent of 20,000 tons of TNT has 20 billion kilocalories, which is no more than the heat of the sunlight which falls on 1½ square miles of land in a day. The difference of course is that in an atomic bomb the energy is wrapped up in a small package and released instantaneously.

Production of Fuel and Food

Of the nearly two billion acres of land in the United States a little more than half is used for farming, and about a third is forest, the rest being largely grazing land, desert, mountains, and city land. Much of our land, therefore, is now making use of the sun's radiation to grow vegetation of some kind—crops, forest or grass —but the utilization of solar energy is often inefficient.

In Table I are shown some of the total crops of the United States for 1946, the yield per acre, the heat which would be released on burning these crops and the percent of the annual solar radiation which is converted into stored heat in the form of plant growth.

Table I. Typical Agricultural Utilization of Sunlight

Crop	*Crop Yield per acre*
Corn (1946 average U.S.)	33 bushels (0.9 ton)*
Wheat (1946 average U.S.)	17 bushels (0.5 ton)*
Hay (tame) (1946 average U.S.)	1.5 tons
Hay (wild) (1946 average U.S.)	0.9 tons
Florida pine (total wood material)	3 tons
Wisconsin aspen (total wood material)	2 tons

We have just seen what average yields are now obtained in the conversion of sunlight into plant material and have learned that two tons of wood material can be grown in a year on an acre of aspen in Wisconsin. When this wood material is burned it will yield 8.5 million kilocalories, whereas the sun's radiation falling on the acre is 20 million kilocalories per day or 7.3 billion kilocalories per year. This results in a return of a little less than one-tenth of one percent of the sun's energy.

The case is somewhat better with corn on fertile soil. On some Iowa farms the yield of shelled-hybrid corn is 100 bushels per acre and the weight of the cobs, leaves, stalks, and roots is about equal to that of the corn. If all this organic material is burned about 20 million kilocalories will be evolved, amounting to a conversion of $\frac{3}{10}$ of 1 percent of the year's solar radiation. If one remembers that the growing season is less than $\frac{1}{3}$ of the year, it is evident that the corn actually converts about one percent of the possible radiation into organic material. According to one experiment in which the light was measured and the corn and leaves and roots accurately weighed, a conversion of 1.6 percent was obtained during the growing season, or about 0.5 percent of the year's sunlight.

What are the factors which make for this low efficiency? As just explained, the growing season is short —only about one-third of the year.

* The additional weight (of cellulose) in stalks and leaves etc. is about equal to the weight of the crop.

The green chlorophyl of plants does a remarkable job of absorbing light all the way from ultra-violet light to red light at 6500 A. and utilizing it in photosynthesis, but even so it can not absorb more than half of the total range of the sun's radiation. Most of the other half lies in the heat rays or infra-red radiation. Again, particularly in the first part of the growing season, the plants are small and much of the acre is not covered with leaves, and the layers of leaves are not thick enough to absorb all the absorbable light. Obviously, it is only the light which is absorbed by the plant that can have a part in photosynthesizing new plant material.

In order to obtain the maximum production, all the conditions must be optimum. For example, if sunlight is to be the limiting factor in getting the maximum amount of plant growth, the other necessary major and minor chemical elements must all be present in adequate amounts. For example, a given amount of sunlight will not give the maximum growth of plant material if the plants are too dry, or the weather too cool, or the ground too poor in soluble essential minerals.

The concentration of carbon dioxide in the air is only 0.04 of one percent and there is no simple way of increasing this concentration in open fields. All plant material gets its carbon from this 0.04 percent in the air. This seems to be a small source of carbon for all the vegetation of the world, but in the air over each acre there is 19 tons of mobile carbon dioxide.

What is the theoretical limit to which efficiency in photosynthesis can approach when all other factors involved are present in abundant quantities and sunlight becomes the limiting factor? Under optimum conditions nearly ten units of radiation called photons must be absorbed by chlorophyl in order to cause the combination of one molecule of carbon dioxide and one molecule of water to give as much carbohydrate as is equivalent to one atom of carbon. These are experimental values, obtained with green algae in water with ample carbon dioxide, perhaps 5 percent, and plenty of chemical food material. As we shall see shortly, this ratio of 10 photons per molecule means that with green light, under the most favorable conditions, only 20 percent of the energy of the light can be stored as chemical energy.

Remembering the ⅓ factor for the growing season and the ½ factor for utilizable sunlight, even with the best environment of moisture, fertilizer and temperature, we could expect to get only ⅙ of 20 percent or 3⅓ percent conversion of sunlight in an agricultural crop in the United States. The 0.3 percent conversion of the annual sunshine in a bumper corn crop is not at all bad in comparison with the theoretical maximum of 3.3 percent.

This maximum ratio of about 10 photons of light absorbed per molecule in photosynthesis was first reported from the University of Wisconsin in conflict with an earlier value of 4 photons. It has since been checked in different laboratories in different ways. The chemical change has been determined by micro-gas analysis, by analysis for oxygen with a mercury electrode, by chemical titration for

oxygen, by differential measurements in a Warburg manometer, and by optical and magnetic methods.

Perhaps the most significant and independent measurements have been made calorimetrically. A tiny glass cell is surrounded by thermocouples which measure the heat evolved when the light passes through the cell. The light absorbed by algae in the cell is measured back of the cell. Of the light which is absorbed by the growing algae, about 80 percent is converted directly into heat in the calorimeter leaving only about 20 percent which can possibly be stored as chemical energy in the carbohydrate and other plant material.

Mechanism of Photosynthesis

We are just beginning to understand something about the mechanism of photosynthesis. With all the millions of dollars invested in agricultural research, it is strange that so little has gone into the fundamental process of photosynthesis which underlies all of agriculture. Practically no studies have been made on photosynthesis by federal or state agricultural laboratories; and active programs of work in quantitative photosynthesis have been going on at only about a dozen universities and institutions. Three symposia on photosynthesis have been held—under the Chemistry Section of the American Association for the Advancement of Science.

The fundamental reaction of all plant life is $CO_2 + H_2O +$ chlorophyl + light $= 1/n(CH_2O)_n + O_2$ + chlorophyl. The light is absorbed by chlorophyl, the green pigment of plants, which remains unchanged while the carbon dioxide and water combine to give a carbohydrate containing carbon, hydrogen and oxygen, which in its simplest unit is represented by the formula CH_2O. When glucose or other carbohydrate material is burned, 112 kilocalories of heat is evolved per mole of CH_2O, and accordingly when CH_2O is formed by the reverse process, at least 112 kilocalories must be absorbed. Green light corresponds to 55 calories per mole and so two photons must be brought together to provide this minimum of 112 kilocalories per mole. Red light of 40 kilocalories per mole requires nearly 3 photons per molecule to meet the minimum energy requirement of 112 kilocalories. In actual photosynthesis, we have found that about ten photons are required for one molecule. Now this use by nature of several low-energy photons to do a high-energy job is unique. We haven't done it yet with inorganic materials and only in the last few years are we beginning to understand how nature does it.

Several laboratory findings have contributed to this understanding. In the first place earlier theories of photosynthesis were handicapped by the erroneous belief that photosynthesis is very efficient, about 60 percent, instead of the now-accepted 20 percent. In the second place, important advances have been made recently in understanding enzyme chemistry and the utilization of energy in yeast, bacteria and other biological systems.

Many miscellaneous facts are known concerning photosynthesis which are

➤ DIRECT UTILIZATION *of solar energy for heating has long been advocated by Dr. C. G. Abbot, formerly secretary of the Smithsonian Institution, who is continuing his researches. He is shown here, on the right, with assistants, on the left, who helped him build this model solar heater in 1936.*

helpful in developing a satisfactory theory. Only a few of them can be mentioned here.

Green chlorophyl absorbs the light and acts as the intermediary for supplying the energy from the sun which is required in the complex series of reactions by means of which the carbon dioxide and water combine to give carbohydrate. Chlorophyl has intense absorption bands in the red and blue but in thick layers it absorbs light throughout most all of the visible spectrum. The maximum efficiency of photosynthesis is nearly the same for red, blue or green light, about 10 photons being required for each molecule. Respiration, which is the reverse of photosynthesis goes on continuously in plants. The plants, like animals, consume oxygen and give off carbon dioxide. The addition of glucose and some other soluble organic foods increases the rate of respiration of plants but it does not affect the rate of photosynthesis.

The ratio of oxygen evolved to carbon dioxide absorbed is often about

1 to 1, but this can be true only for the production of cellulose and other carbohydrates. The ratio can not be unity in those plants and algae which produce considerable amounts of proteins and fats. An exact determination of the oxygen-carbon dioxide ratio is helpful in giving information concerning the composition of the organic materials produced in photosynthesis.

The photo-reactions pile up fresh organic material which is used by the plant in a series of reactions which go on in the dark. Valuable information concerning the dark thermal reactions and the photo-reactions has been obtained by exposing plants to intermittent light with dark periods ranging down to fractions of seconds. Again the dark and light reactions can be partially distinguished by changing the temperature because the dark reactions are accelerated by an increase in temperature whereas the photo reactions are nearly independent of temperature.

One of the newest and most promising attacks on the mechanism of photosynthesis lies in the use of isotopic tracers. When plants are grown in carbon dioxide which contains radioactive carbon, the first chemicals produced in photosynthesis are identifiable by means of their radioactivity. Active and significant work is now going on with radioactive carbon. Experiments with water containing the heavy isotope of oxygen revealed the significant fact that the oxygen released in photosynthesis comes from the water, and that the oxygen of the carbon dioxide remains in the plant materials.

With the help of these laboratory findings and many others a satisfactory hypothesis is beginning to unfold. Apparently the carbon dioxide and water form first an organic substance of moderately low molecular weight which contains both a carboxyl group, characteristic of organic acids, and a hydroxyl or OH group. Following the primary photo reactions are many thermal reactions which are aided by enzymes. The over all energy requirement of 112 kilocalories is too great to be met by one unit of light, one photon, and so the reaction is carried out in a series of steps, one photon being used for each step. Apparently light with the help of chlorophyl removes hydrogen atoms from intermediate chemical compounds and adds them on to CO_2 to give CH_2O. The hydrogens come originally from the water and pass through compounds such as peroxide which evolve oxygen when they react. Perhaps four steps are involved, each requiring a photon; and then four more reactions with four more photons are required to restore the hydrogen atoms to these intermediate compounds, ready to be used again. This gives a total of eight photons through a series of eight intermediate steps which carry the hydrogen from the water to the carbon dioxide thus releasing oxygen and forming the carbohydrate material, CH_2O. If this picture, proposed by Professor James Franck, is correct we have a plausible explanation for the experimental fact that about ten photons are required.

The Next Hundred Years

When it comes to predictions, the news reporters probably take delight in pushing the scientists way out on a limb—just for the fun of seeing the splash. However, on this hundredth anniversary there may be a legitimate demand for a little speculation.

The days of easy geographical quest for more food, fuel and power are over and our frontiers now lie in science and engineering. We can no longer afford to waste fuel in fireplaces and stoves that send most of the heat up the chimney nor in low temperature engines that are thermodynamically inefficient. In the future it will be necesary to control the birthrate of the world's population and to increase the efficiency of our utilization of sunlight. We have seen that we are now using a small fraction of the solar energy which is available, and that theoretically we should be able to appropriate a much greater part of it.

Our discussion has emphasized the situation in the United States because it was difficult to obtain statistical information regarding the utilization of sunlight over the whole world. We are emphasizing on this anniversary occasion, however, that science is world wide. Let us add, then, that the area of the United States is but a small fraction of the earth's surface and that any improved conditions must be thought of in terms of world application. In the tropics there is a greater opportunity for utilizing solar energy because the energy is greater than the 1 kilocalorie per square foot per minute in the United States and the growing season is not confined to a third of a year. The soil and certain agricultural conditions are somewhat less favorable however. Also to be considered are the great areas covered by oceans where photosynthesis goes on in algae, diatoms and sea plants. Probably five times as much organic material is being produced now in the sea as on the land.

It is possible now to grow plants without soil, using barren sand or tanks of water containing the necessary chemical elements. This science of hydroponics has been developed to a point where such operations are practical, even if not economically competitive except in special areas. Probably the utilization of sunlight can be made more efficient in this way and the operation can be carried out where there is no soil suitable for ordinary farming.

Let's consider one step further. What chance is there that we can combine carbon dioxide and water to give organic material without the agency of a living plant? Can we perhaps find some combination of colored dyes and enzymes which will do what nature now does with green plants? This has not been done yet, but there is no obvious theoretical reason why it can not be done some time in the distant future. As a matter of fact if some one had asked me to guess ten years ago which would come first, atomic energy or photosynthesis without the living plant, I would have guessed that photosynthesis without plants would come first. But now we have atomic energy —or at least we *can* have it. We got it from the unexpected discovery of

fission and an investment of 5 years of intensive cooperative research by many hundreds of scientists and engineers, and the expenditure of 2 billion dollars. The corresponding investment in research on photosynthesis has been negligible.

Even if we could produce food without the growing plant our present farms would not fear competition from the cheap land and bright sunshine of Arizona. Any type of artificial photosynthesis would probably require shallow tanks possibly of concrete covered with glass and the investment would be too great to consider in economic competition.

Looking less far into the future, what important changes are apt to come?

We will have to find ways to increase the food and fuel supply of land areas which are not suitable for growing standard food crops. The wheat and meat of the limited, rich-farming lands can not be used indefinitely to feed the world. Trees and quick-growing bushes and grass can be grown on poor soil and it is now perfectly practical to eat wood products. Sixty-five to 70 percent of most woods can be converted into sugars by heating with dilute sulfuric acid to 120° to 150° C. under special conditions developed at the U. S. Forest Products Laboratory. This material can then be used for growing yeast and producing alcohol which can be used for liquid fuel. The wood yeast is richer in proteins than beef steak and can be used for food. In fact thousands of tons of wood yeast were used for human food in Germany during the war. These cellulose yeasts are very cheap and possess splendid nutritive value. With intensive research on improving the flavor, this source of protein should be of great help in solving a food shortage, particularly in the tropics where the large-scale production of meat is difficult. Nitrogen compounds must be supplied to these growing yeasts in order that they can produce proteins. Possibly this fixed nitrogen can be supplied from the nitrogen of the air by a new process in which the air is heated to a high temperature. Present methods of utilizing sunlight to increase proteins include the feeding of plant material to chickens, hogs and cattle. Fish farms should probably be expanded in certain areas. Intensive research should be directed toward utilizing algae and sea weeds for food. They can be hydrolyzed to produce sugars which can be used directly as food, or as a means of producing edible proteins from yeast. The supply of aquatic vegetation in the oceans is enormous; and in fresh water lakes and streams the algae and weeds should be harvested anyway because they are often a nuisance.

The utilization of farm products for local fuel is another development that is just around the corner. If farm prices fall it may be more difficult for the farmer to pay cash for gasoline and oil for the tractors that have replaced the hay-eating horses. Wood and corn stalks and other cellulose material have been converted into alcohol—60 gallons to the ton. New developments of the Fisher-Tropsch synthesis of hydrocarbons assure us that it will be possible to convert waste organic material into carbon monoxide and hydrogen, which with the help of iron and cobalt catalysts,

can be converted into satisfactory motor fuels. Research should be directed toward developing medium sized units, like dairies, for local farm areas.

Some of these developments which I have suggested will come slowly, not because of technical difficulties, but because of economic circumstances. For the present nature has supplied man with such abundant sources of fuel and food that he will not be pushed to these new things for some time unless we continue to have unequal distribution among the nations of the world due to war and political short sightedness. It is comforting however to know that we can get more from the sun when we need it and that theoretically at least the scramble for oil and coal could be eased.

Science must go forward, regardless of immediate practical applications, accumulating a reserve stock of knowledge which can be used in any emergency. We must learn how to use our rich heritage of sunlight more efficiently so that we can be prepared against such catastrophies as war, overpopulation, exhaustion of oil and coal, or the return of the glaciers. The scientists too must cooperate with the social scientists and statesmen so that adequate preparations can be made for any social, economic, and political readjustments which may follow the scientific developments.

Fertilizer Budgets Nitrogen

➤ SELF-BUDGETING fertilizer, which can supply nitrogen to plants at a predetermined rate over extended periods of time, is now being developed.

The new fertilizer is a synthetic material called urea-form, because it is made from urea and formaldehyde, Dr. R. O. E. Davis of the Bureau of Plant Industry, Soils, and Agricultural Engineering, Beltsville, Md., told the American Chemical Society.

A series of products suitable for fertilizer can be obtained by combining urea and formaldehyde.

The nitrogen content ranges from 36 to 38 per cent and is in a much less soluble form than the present nitrogen fertilizers. Changing the ratios of reactants changes the solubility of the product and the rate of nitrogen release.

On the Back Cover

➤ "NOT BAD," *says Dr. Farrington Daniels, of the efficiency with which corn utilizes the energy of sunlight. But plants can run their energy utilization systems only during the short growing season. Scientists hope to learn their secret and keep it going the year round.*

New Protein Found in Blood Is Fifth Factor in Clotting

News of Blood and Vitamins

➤ A NEW PROTEIN which plays an important role in clotting has been discovered in blood.

The new blood-clotting factor was described to the International Society of Hematology at its Buffalo, N. Y. meeting by scientists from this country and Norway.

Dr. Paul A. Owren of the University of Oslo, Norway, reported that he found the protein in 1944. He called it the fifth coagulation factor. Working independently last year, American scientists located the clotting factor and termed it ac-globulin. The "ac" is for accelerator, because it is one of the triggers that sets in motion the clotting process.

Four previously known substances are all necessary to produce clotting in blood. Prothrombin, a blood protein, must be activated by thromboplastin, a substance present in tissues, and calcium to form thrombin. Thrombin is the intermediate substance that acts on fibrinogen, the fourth factor necessary in coagulation to form the blood clot.

How ac-globulin, the new fifth blood-clotting factor, helps produce prothrombin was explained by Drs. Walter H. Seegers and Arnold G. Ware of the Wayne University College of Medicine, Detroit.

Their work has been aimed at isolating the new factor in pure form in a laboratory test tube. Although it is difficult to separate, they said that they are very near to getting the substance in purified form.

The Norwegian scientist who first discovered the new protein reported that he has successfully treated one patient with it.

Dr. Owren said the patient came to his hospital clinic with a very rare bleeding disease which the Norwegian doctor calls parahemophilia. After treatment with this new clotting factor, supplied from normal human plasma, the patient was relieved of her bleeding tendency.

Because the disease is so rare, physicians say that at present they have no way of knowing how often it might occur. Only a few cases have been reported in the U. S.

Protein From Blood

➤ A SAFER, simpler and less expensive method for extracting disease-fighting proteins from blood was disclosed to the International Society of Hematology.

The use of this method would reduce the risk of having the jaundice virus transmitted from plasma and also make available at a reasonable price the albumin needed for shock and burn patients and the globulin which is needed by bleeders, according to Dr. Allen F. Reid and Frances Jones of the Southwestern Medical College, Dallas, Texas.

In this method the salts, which hold the blood molecules in solution, are removed with ion exchange resins,

leaving the blood proteins. This method, moreover, can utilize plasma that would get too old, or even old blood that has been stored.

By using only natural conditions to fractionate the blood, the proteins do not lose any of their natural properties such as anti-bodies. Any blood bank or medical center can produce its own material without need of the close engineering control for which only large laboratories have facilities.

Of special importance is the fact that human albumin can now be used as a substitute for plasma. Only one company is at present producing albumin because it requires controlled temperature, which means extensive laboratory facilities, and because it costs the patient $30 to $40 a shot. Most patients cannot afford this.

Moreover, since albumin comes from pooled plasma that may contain jaundice virus and there is no safe method of sterilizing plasma when alcohol is used as in present procedures, the patient is endangered.

These scientists report that with their method the albumin can be pasteurized to kill the virus and thus make injections absolutely safe.

Vitamins From Protein

➤ THE BODY may be able to manufacture some vitamins from proteins if it does not get enough vitamins from food, the International Society of Hematology was told.

Discovery that some vitamins can be made from proteins was made in experiments with rats, but the findings may apply to humans, Dr. Floyd S. Daft of the National Institutes of Health, Bethesda, Md., declared.

Dr. Daft found that if there are not enough vitamins and amino acids, chemical building blocks of proteins, in the diet of rats, they develop blood disorders. The nutritional anemia may be caused by a shortage of protein material to manufacture the missing vitamins, Dr. Daft suggested.

Rat experiments indicate that a diet slightly deficient in tryptophane, an amino acid, produces a shortage of the vitamin, folic acid. When the rats were treated with either of two vitamins, niacin or folic acid, they recovered from the anemia.

When the vitamin was given the rats, Dr. Daft said, it seemed to increase the supply of protein, because the protein was no longer used in vitamin-building.

Rats put on a diet in which casein, the principal protein in milk, was the only protein showed growth failure and frequently developed blood disorders. Adding three protein-building amino acids to the diet prevented this condition from developing.

But after the blood condition had developed, one or more other substances such as amino acids, folic acid or purified liver extract were generally needed.

Thus, Dr. Daft concluded, vitamins can help correct a protein deficiency, while proteins will aid in building up the supply of vitamins.

If a diet is low in protein, there will develop shortages of both vitamins and nucleic acids, the basic substance in the nucleus of a cell.

The findings with rats may apply to humans, Dr. Daft said, because both rats and humans respond to the same treatments with vitamins for certain types of anemia. Folic acid

and the new vitamin, B-12, correct these anemias in both, it was found.

How sulfa drugs work in the body may be explained further by discovery of this interchange between vitamins and proteins, the scientist indicated. Dr. Daft previously found that sulfa drugs cause anemia and destruction of white blood cells in rats. His new experiments have led him to believe that sulfa drugs may create an amino acid shortage in the body.

Trouble From Vitamin Lack

➤ LIVING on a diet which does not contain enough of the vitamin B complex ordinarily obtained from meat or whole grains causes mental abnormality. This was found in an experiment with a small group of men patients at the Illinois State Hospital at Elgin.

The changes come slowly and insidiously, if the dietary deficiency is not drastic. Decline in mental ability may not be noticed until after about 18 months of poor diet and then no one can be certain of a definite date when the symptoms started.

Men who had been moving about actively, helping in the ward work or talking to one another, lost interest and ambition, became dull, sat in their chairs or lay on their beds. They were disinterested in their surroundings.

These symptoms occurred in one group of 12 men patients whose diet contained plenty of all the essential nutritional elements except that the vitamin B content was reduced from a normal 1,200-2,000 micrograms to 400 micrograms, or about a third of normal. (A microgram is a unit of weight equal to 35 billionths of an ounce). The riboflavin was cut from a normal of 1,600 to 2,600 to 800 micrograms, or about half.

Much more dramatic results occurred with another group for which the riboflavin intake was cut to 800 daily and the thiamin to 200 micrograms.

After only four to six months on this more severely restricted diet, mental abnormalities became much worse. One old man who had been quite amiable, became infuriated and threatened to break up the furniture and escape. A young man who had been subject to bad temper fits which ordinarily lasted a minute or so, once or twice a year, went into blind rages.

These occurred in quick succession and lasted a half hour to an hour. During this time, he would scream at the top of his lungs, throw heavy objects at anyone within reach and curse at the women attendants.

Just as dramatic as the onset of these symptoms was the recovery when the inadequate diet was supplemented with yeast extract to provide the missing vitamin B.

The rage of the terrible-tempered old man subsided overnight and he became his former amiable self again. The young man who had endangered the lives of all around him, appeared self-controlled the day after he was given the vitamin B. Only one old man took several weeks to regain his former contentedness.

Patients on the less severely restricted diet whose mental abnormalities had been very slow and gradual in development were also comparatively slow in recovery.

Persons who have a low energy output can get along for a longer period on a diet lacking somewhat in vitamin B, the investigators concluded. They found that the regressed patients with schizophrenia, who ordinarily have interests and ambitions dulled and are relatively inactive showed the changes later than did the patients with cerebral arteriosclerosis and other mental illnesses not associated with general decrease of energy output.

Because of the slow and insidious way that mental symptoms appear, it is not possible, the investigators feel, to be sure that a diet is not dangerously deficient in vitamin B, if study of it is not continued for at least two years. Details of the study are reported in the *American Journal of Psychiatry*.

Chemicals Fight Leukemia

➤ Two CHEMICALS derived from the vitamin, folic acid, are proving effective in fighting cancer and leukemia, the American Pharmaceutical Association was told in San Francisco.

Cancer patients have less pain and reduced need for narcotics when treated with pteroyltriglutamic acid, James H. Boothe of the American Cyanamid Company reported.

He said that some cases have been reported in which tumors were arrested by treatment with the chemical. But, he emphasized, further study will be needed to determine its effectiveness as more than a pain-killer.

Another member of the folic acid family has aided several children suffering with leukemia, Coy Waller, also of the American Cyanamid Company, told the meeting.

The chemical, aminopterin, was used to treat leukemia at Children's Hospital in Boston after it had been successfully tested against the disease in animals.

This chemical checks the overproduction of leukemic cells, but it is difficult to use clinically because of undesirable reactions from the toxic compounds.

New Rat-Killing Chemical

➤ CASTRIX is a poison even rougher on rats than the new ANTU and 1080. Prof. Kenneth P. DuBois developed the compound from a German formula in the University of Chicago's Toxicity Laboratory on a project sponsored by the U. S. Chemical Corps.

Castrix is at least five times more effective than ANTU and 1080, is readily accepted in rat baits, and does not produce a tolerance if it fails to kill the first time. It produces violent convulsions, which end in death in less than an hour.

Like 1080, it is poisonous to dogs, cats and other animals; but it has effective antidotes in the barbiturates, already widely used in human medicine as sleep-inducing drugs. An animal given 20 times the ordinary lethal dose would recover after the administration of a barbiturate, even though convulsions had set in. Castrix is thus the only highly toxic rat poison that has an effective antidote.

Chemical Raw Material, Liquid Gas, Fuel and Oil Refinery Stock Are Butane Uses

Butane Can Increase Gasoline

➤ THE BEST use of the butane obtained in refining petroleum or from natural gas is a major problem in the liquid fuel industry.

The yield of butane-butylene fractions obtained in the processing of petroleum is appreciably in excess of the amount that can be blended directly in motor gasolines without exceeding accepted vapor-pressure limitations.

T. L. Apjohn and D. P. Heath of the Socony-Vacuum Oil Company have told the American Petroleum Institute that the refining industry as a whole has at its disposal four principal uses for its excess butane. These are as refinery fuel, as a raw material for chemical and rubber manufacture, as liquefied petroleum gas, and as a charge stock for conversion to a liquid product through further refinery processes.

Its use as a refinery fuel is uneconomical. The amount required for chemicals and rubber production is limited. Considerable quantities can be well used in making liquefied petroleum gases for domestic and industrial fuel purposes. In order to utilize excess butane-butylene fractions, most refiners are faced with a choice of converting them into liquid products that can be blended into motor gasoline or adding the butane-butylene directly. This latter increases the vapor pressure of the gasoline.

Although crude-oil and motor-fuel production have both been greatly increased in recent years, the potential availability of butane from natural gas resources has also shown an increase by an even larger amount, the Institute was told by R. C. Alden and T. W. Legatski of the Phillips Petroleum Company, Bartlesville, Okla.

A considerable expansion of extraction and recovery facilities is now in progress, based on the relatively low value in ordinary uses as compared with the higher values when this material is used in motor fuels. The inclusion of the butane in motor fuels would effect a volume increase of some 13 per cent in our motor fuel production. This would be equivalent to refining an additional 600,000 barrels of crude oil daily.

Picture in Only Four Seconds

➤ A CAMERA which develops moving photographic paper or film four seconds after the picture is snapped has been developed for medical use.

Claimed as the fastest complete developing process yet achieved, the new camera may have applications in fields of photography other than medical. The camera is produced by the Beck-Lee Corporation, Chicago.

Diastatic Enzyme Concentrate In New Liquid Form Announced

Quicker Desizing for Textiles

➤ Sizing of cotton yarns represents one of those unavoidable detours which vex production men in many segments of industry. In the textile industry, it means that cotton yarn has to be coated or "sized," usually with starch, to protect the fibers against abrasion which they must withstand in later handling. Unfortunately, the sizing must be removed before the cloth is bleached, dyed or printed. This sizing has nothing to do with finishing processes applied just before the goods is delivered in bolts to the drygoods counter or dress manufacturer.

To insure uniform wet-processing of textile yarns, the desizing chemical is asked to rid the fiber of all possible impurities—a job which for generations has delayed the processing and increased the cost of one of the world's staple products. Modern chemistry, however, has harnessed the behavior of enzymes—popularly described as natural organic catalysts—to speed up the desizing operation and make it much safer than earlier methods, such as acid desizing. Continued development of this technology has finally made feasible the elimination of batch processing and the adoption, already effected in a large number of plants, of the continuous method.

Now a liquid desizer, just announced, offers the proved advantages of the powdered enzyme concentrates, but in a more convenient form and with a marked reduction in cost.

Acid desizing consisted of soaking the cloth in a solution of dilute sulfuric acid, which so hydrolized the starch size that it became water-soluble and could be washed from the fabric. In this process, which is still used to some extent, the time factor is most disturbing; the soak requires four to twelve hours or longer. Worse, there is the danger of damaging the fabric as the acid tends to modify the cellulose structure. Then, in addition, the oils and softeners used in the warp size mixture sometimes break down or oxidize during the acid treatment and become difficult to remove.

Enzyme desizing brought a safer and better method. It converted the starch to soluble compounds so gently that the fabric was not endangered; the method did not affect processing oils or softeners, and the enzymes themselves did not interfere with the other chemicals used in processing.

However, the enzymes first used were relatively slow acting; soaking for many hours, and sometimes overnight, was still required. In addition, most enzymes used in desizing are heat-sensitive, demanding careful temperature control of the steep bath. Gradually, chemists learned to handle the enzymes at successively higher temperatures which stimulated their activity and reduced the soaking time required; nevertheless, control was

critical and stability of the enzymes far from ideal.

Then, some years ago, the Rohm & Haas Company introduced Rhozyme DX, a diastatic enzyme powder, and other powdered concentrates, which possessed remarkable heat resistance: their speed of action remained virtually constant throughout a four-hour period at 140° F, dropped less than 20% at 160° F and even remained effective for as long as an hour when used at the previously extreme temperature of 180° F.

These enzymes, obviously, made possible a marked increase in desizing speed for many types of textile materials. Further investigation increased their usefulness. Kettle desizing of spun rayon fabrics was performed in 30 to 45 minutes with Rhozyme DX used at 180° to 190°. Still later, it was found that this durable enzyme could withstand even a brief exposure to steam; at such temperatures, desizing was virtually instantaneous. Here, patently, was the answer to the time-consuming soak in the enzyme bath.

Subsequent plant testing has made continuous desizing a commercial reality. Under the guidance of Rohm & Hass technicians, a number of finishing plants have installed equipment to handle their full production on this basis, with a resultant impressive saving in processing time. One plant whose desizing operation formerly included an eight-to twelve-hour soaking period, for example, now does the job completely in minutes. The enzyme is padded on and the fabric taken continuously through a steam chamber at about 140 yards per minute; the starch is solubilized and the fabric goes straight to the wash and subsequent processes.

Another mill, finishing a heavy fabric which previously required two days' soaking, now passes the fabric twice through the enzyme-steam-wash cycle and completes the entire process in a few minutes. When the cloth enters the steamer, the enzymes begin a feverish attack on the starch molecules, breaking them down into smaller, water-soluble units. Then the enzymes themselves are destroyed. Probably, desizing is completed and the enzymes inactivated in only a few seconds after the cloth enters the steam chamber.

The new addition to the Rhozyme family of textile desizing-agents produced by Rohm & Haas is called Rhozyme LA, and is distinguished particularly by its liquid form, in contrast with the powdered materials formerly supplied. Pound for pound and when used in the same application, its cost is one-third less than that of the powdered desizers.

Because it goes into solution readily, it lends itself perfectly to continuous high-speed desizing throughout the industry. The new enzyme is said to maintain the stability under high temperatures which the powdered concentrates exhibit.

In swiftly changing markets — a normal hazard in the textile industry —rapid conversion of gray goods to finished fabric is vital, in order to minimize the danger of disastrous price changes while the cloth is being processed. Continuous desizing speeds finishing on a production line. Rhozyme LA reduces the cost.

Rare Atmospheric Gas Useful in Illumination

Krypton Fills New Lamps

➤ FLUORESCENT LAMPS, using krypton gas instead of argon, have recently been developed by Westinghouse. They give higher efficiency and, therefore, will decrease electric light bills.

Krypton, one of nature's rarest elements, is used in a new gas-filled 85-watt fluorescent lamp. It provides a 17% gain in efficiency over the generally used argon gas, Dr. A. M. Hageman of the Westinghouse Lamp Division states. The 85-watt lamp provides as much light as the 100-watt argon-filled lamp it replaces, and matches its predecessor equally in good maintenance and other features.

Krypton is one of the rare gases found in very small quantities in the atmosphere. The others are helium, neon, argon, and xenon. They are all inert and exist in "trace" quantities. They can be separated by the distillation of liquid air. The substitution of argon for the formerly used nitrogen in electric lamps has saved many millions of dollars. Krypton promises even a greater saving.

Other applications of the inert gas in lighting have already been made. Krypton is used in a Westinghouse miner's incandescent lamp. A quartz tube lamp Westinghouse developed for the airport approach lighting system of the New York International Airport (Idlewild) is filled with this gas. The lightning-like flashes from these lights are designed to pierce even zero-zero weather for at least 1,000 feet, as guides to the runway.

America's foggiest airfield at Arcata, California, is to be equipped soon with an all-weather approach lighting system which will be visible to pilots in Arcata's heaviest fog for at least 1,000 feet. The most brilliant of the lamps will contain krypton.

The system to be used will include 36 of these world's brightest lights, and 35 lights of somewhat lesser brilliancy. Lined up in a row two-thirds of a mile long, the 71 lights will produce lightning-like flashes to guide fog-bound pilots to the runway.

The 36 krypton flash units will be placed in line alternately with 35 neon units. When flashed from one to another in the wink of an eye, the lights will appear like a flash of lightning to a pilot in the air.

A six-light Westinghouse approach-lighting system has been in use experimentally at the Cleveland Airport for over a year. The first commercial installation of a full approach system has just been made at New York City's new International Airport. For the real acid test, however, conditions at the armed forces Landing Aids Experiment Station at Arcata are ideal. The fogs are even denser than those on the Atlantic coast. All sorts of aids for bad weather landings are on trial at this station. The lights to be used are four-inch long slender quartz tubes filled with krypton, and have a peak capacity of 3,300,000,000 candlepower each.

The Home Lab as a Hobby

"With all thy getting, get understanding"

by Burton L. Hawk

In a facetious vein, a hobby may be defined as "work without compensation." This may be true, for what may be a hobby for one person may be a means of livelihood for another. However, a good hobby will provide a pleasant diversion which can bring both relaxation and stimulation.

Who

Obviously, the hobby you choose will have to be in a field which occupies your highest interest. We assume that you have an interest in chemistry or you probably would not be reading this article. You enjoy reading magazines and textbooks about chemistry? You liked the chemistry course in high school? And you relished the performing of experiments in the school laboratory? You are fascinated at the revealing of new facts and formation of new substances through research? Then why not construct a lab of your own; perform your own experiments; do your own research? A college degree is not required, neither is it necessary to be a skilled technician. All you need are the *interest* and *desire*. You must not force yourself into it. Perhaps the study of science seems dull to you in detail and you care only to keep posted occasionally on important developments. Then you must pursue a hobby in another field of more interest to you—perhaps music, art, or sports.

A chemist is a strange person. He mixes poison, caustic acids and harsh alkalies. He chokes in pungent mists, coughs and gasps from poison gas, is sickened by vile-smelling vapors. Yet in this he finds real joy and stimulation!

Why

The ever-changing and constantly growing science of chemistry provides unlimited experimentation. Certainly work in the home lab will not be monotonous. When you consider that absolutely *everything* that exists is the result of a chemical reaction, you can realize the magnitude of this science. Consider also that *one element*—carbon—is capable of producing 300,000 known compounds and it is still possible to prepare thousands of others!

The complexity of chemistry presents a challenge, which taxes the ingenuity of man. This brings fascination and mystery, for a subject easily mastered just as easily becomes tiresome.

Chemistry is a young science, still rapidly growing. There are still many unexplored paths to follow, many things that need explanation and clarification. There will always be something new. Certainly the study of chemistry will not lack stimulation.

How

By now the question may arise as to how a home lab can be established. First a suitable location must be

found. A corner in the cellar would probably be best, preferably near a window. Running water and gas would be convenient but not absolutely necessary.

Next, find or construct a suitable work bench. The basic requirements are that it be sturdy, of convenient height, spacious, and covered with a suitable washable material, such as linoleum or a slab of marble. If you have running water available, you would allow space for a sink at one end of the bench. If not, keep a large pitcher of water handy and a bucket or large jar for waste. Or if you wish, you can construct a siphon arrangement. Shelves can be built on the wall next to or in back of the table.

Now you are ready to stock your lab. It is rather difficult to list what should be purchased at first. Perhaps the best thing would be to purchase one of the many chemistry sets on the market today—for about five or ten dollars. This will provide you with a varied selection of the more common chemicals. From time to time, purchase more chemicals and apparatus and in this way gradually enlarge your laboratory without too much financial trouble. Start from the bottom; you cannot expect to obtain a well-equipped laboratory overnight.

At first, perform simple experiments. Later purchase a good textbook and perform some of the experiments described in it. Experiments appear periodically in many scientific journals such as those in this series—designed primarily for the home lab.

As your laboratory progresses, so you will progress to more difficult and fascinating experiments. Soon you will find that you will be performing experiments of your own—following minature projects of your own. Here you will experience a new kind of pleasure, a creative pleasure, the joy of discovering things for yourself!

Some may question the danger of a home lab. A home lab is no more dangerous than any other hobby, if you simply abide by one principle: *Use common sense!* Naturally, you will handle corrosive liquids and dangerous poisons carefully. You will provide yourself with adequate protection when experimenting with explosive mixtures. And of course you will not expose inflammable liquids to open flames. Do not mix everything together, "to see what will happen." Think out your experiments before performing them. Investigate the subject and deduce what will happen—then proceed with proper preparations.

Neatness is an important factor. Nothing is more discouraging than an untidy, unkempt lab. Keep all of your chemicals properly and neatly labeled and arranged on the shelves in systematic order so that you may locate them quickly. Wash all dishes after each experiment and keep all apparatus clean. Dirty containers can spoil many experiments.

Finally, go to it and have fun! Learn all you can and observe all you can. Remember some of the greatest discoveries were made by young men experimenting in home-made laboratories! America needs scientists—and well may the home lab enthusiast of today become the scientist of tomorrow!

British Scientist Describes Centers of Crystal Study

Bragg On X-Ray Analysis Centers

In his presidential address before the Section on Physics and Mathematics of the British Association for the Advancement of Science, at its recent meeting at Brighton, England, Sir Lawrence Bragg, son of the late Sir William Bragg, described current developments in crystal analysis. Soon after Laue's discovery of X-ray diffraction by crystals, the elder Bragg in 1912 began to use that principle to map crystal structure, enlisting his son's interest in the problem.

In the extract here reprinted from Sir Lawrence Bragg's address, the roll is called of many laboratories in England which are using this direct method for determining the molecular structure of many different kinds of chemical compounds.

➤ Our country has played a leading part in the development of X-ray analysis from the first. Doughty exponents of this art are to follow me this morning, and give an account of their recent researches. But we now have so many centres of X-ray analysis in this country that it has been no easy task to choose a team to play for the side. Most of our experts came originally from three schools of research, my father's group at the Royal Institution, the Crystallographic Laboratory at Cambridge where Bernal inspired so many fruitful new lines of work, and my school at Manchester. But I cannot forbear contemplating with considerable pride and complacency all the active centres where work of first-rate importance is now being done, and I have taken as the subject of my address a review of these centres. It would perhaps be logical to arrange my matter under subject headings — minerals, organic compounds, metal structures, and so forth, but I do not propose to adopt this plan. I see the development of X-ray analysis as due to a number of centres, inspired by original and brilliant leaders, and I wish to consider some of these centres in turn and describe their work. I wish I could deal with them all, but this would take too long, and I can only give a very brief and superficial review.

Pioneer

It is natural to speak of Bernal's work first because no one has done more than he has as an explorer and pioneer. Time and again, when reviewing some branch of X-ray analysis which is now very active, we have to acknowledge that the first critical experiment was due to his inspiration. Settlers have moved in to farm the land, but he has been the pioneer who pushed the frontier forward; one may add that, like all true pioneers, he becomes impatient and restless when the new country is developed, and moves to fresh fields! As I have worked in X-ray analysis from its start, I am perhaps as well placed as anyone to judge what his contributions have been, and remember the

impressive novelty of lines of approach which we now all take for granted as well established and classical methods. In the early days we painstakingly examined X-ray diffracted beams one by one with an ionisation chamber. Highly accurate analyses are now made by the far more rapid method of recording all the beams on a photographic plate. The method itself was not new, but it was Bernal who showed us how to systematise and docket the observations and draw logical and far-reaching conclusions from them about the architecture of complex compounds. The paper by Bernal and Fowler on water will always be a classic, as showing how much information could be got from the diffuse X-ray haloes produced by a liquid. I well remember his first review of metal structures and the wide generalisations he made. It was he who first obtained a regular diffracted pattern from a protein crystal, a subject of which we are to hear more from Perutz this morning, and he advanced further to study the scattering by the very large scale regularities in virus preparations. These fields have now been far more intensively studied; his work only gave an indication in each case of what might be discovered, but it made the first steps possible.

Heat Ripples

Another centre in London will be represented this morning by Mrs. Lonsdale, who started her investigation of diffuse X-ray scattering at the Royal Institution. The analysis of crystal structure is based on diffraction of X-rays by the regular pattern of the crystal. Each periodic variation in density due to the repeat of the pattern reflects a corresponding X-ray beam. However, any periodic variation of density produces the same effect, and consequently the thermal waves in a hot crystal diffract X-rays, as was first shown by Guinier and Preston. I can leave it to Mrs. Lonsdale to tell you about her development of this subject, and will merely say how interesting it is that X-ray analysis should find such an unexpected application, as a harmonic analyser of the elastic ripples running in all directions in a hot body. Mrs. Lonsdale was one of the first two women ever to be elected to Fellowship of the Royal Society. She was shortly followed by another X-ray crystallographer, Mrs. Hodgkin, and we may claim with pride that X-ray crystallography has indeed contributed to history by providing a field in which they established their reputations.

Penicillin

Mrs. Hodgkin is to tell us this morning about her work on penicillin, and no better example could be found of the art of crystal analysis. I would like to remind you of some characteristics of this art. The experimental work consists in recording, indexing and measuring a large number of spectra or diffracted beams of X-rays, each of which corresponds to a periodic element in the crystal pattern. The number of these measurements often rises into four figures. These periodicities must be accounted for by the arrangement of the atoms, and the more complex the crystal, the larger is the number of co-ordinates which are needed to define the positions of the atoms. The progress of

crystal analysis can be measured by the increase in the number of co-ordinates or parameters which can be dealt with. In the first structures my father and I analysed in the early days, the atoms were at points of symmetry and there were no parameters to determine. An early triumph was the analysis of crystals with one parameter such as calcite and pyrites. But nowadays crystals with anything up to one hundred parameters are confidently tackled, a task which would have seemed almost beyond the bounds of posibility to the early workers. The inherent difficulty of such work consists in its being very rarely possible to deduce the structure directly from the observations. On a strictly analytical basis, the observed diffractions might be caused by an infinity of structures since the relative phases of the periodicities do not affect the strengths of the diffracted beams, and the solution only becomes unique when we impose certain conditions, in general that the pattern-unit consists of a discrete number of atoms of known form. No way has as yet been found of arriving directly at a solution consistent with these conditions by a mathematical treatment, though attempts to do so have been made, and crystallographers have to fall back on a process of trial and error. In effect, one has to guess a likely structure, calculate how it would diffract, and compare with observation; if there is no correspondence, a fresh guess has to be made. So in solving a crystal with one hundred parameters, one is trying to guess successfully all their values simultaneously.

The observations themselves are generally not difficult to make. Sometimes a crystal is very small, or unstable, sometimes it is difficult to get a perfect specimen. But on the whole the making of the observations is a matter of routine. The real work lies in their analysis. So in an X-ray laboratory one finds a deserted room full of apparatus in which the photographs are taking themselves, and a series of annexes in which absorbed workers are wrestling with masses of observations and calculations. I always find it an interesting contrast. Here on the one hand are a few photographs of some unknown structure. Hidden in the pattern of diffracted spots lies all the information required to establish the structure, if only one can find the 'open sesame' which would reveal the treasure. The material is so simple, the analysis so very difficult.

Jig-Saw Puzzle

How is it done? The analyst has before him the separate bits of a jig-saw puzzle, each one of them being a periodic element in the structure, and he has to fit them together so that they build up a picture which makes sense, meaning by this a distribution of scattering matter corresponding to the atoms which he knows to be there. In making guesses at possible arrangements, he draws on a wealth of experience of the way atoms associate together in space, obtained from previous analyses. He pushes the atoms this way and that, remembering as he does so the many other alleys he has previously explored which have proved to be blind. It is, alas, a long time since I last analysed a structure personally, but I can well remember

the intense concentration. One lived with the structure, I am tempted to say one ate, slept, and shaved with it. Finally, after six months or longer, and if one were fortunate, everything suddenly clicked into place. An arrangement was found which fitted so well to the most important observations that it was clear that one was on the right track at last. Once the general scheme is discovered, the final adjustments are relatively easy, and one more example is added to the growing list of known structures. Again there is a curious characteristic of this crystal work; we can be sure of our results. Further refinement may be made later, but the evidence that our guess is right in the main is quite overwhelming and certain.

Expert Needed

These analyses take a long time, and can only be made by the expert. What is the reward which lures him on to concentrate so intensely on establishing a picture of some twenty or thirty atoms arranged in a pattern? There are so many structures to do, and so few people who can work them out, that it seems an endless task to examine them all. But it is not really so hopeless, because the successful analysis of one structure often leads to a quite new understanding of a whole range of forms of matter. The structure of diopside, for example, marked the turning-point in our understanding of the nature of all silicates; the structures of one polyacid shows how they are all built up; the structure of a few simple salts led Pauling to formulate the rules which determine the structure of inorganic compounds in general. It is all the more important that really key structures should be chosen for examination, as likely ventures in which it is justifiable to sink one's capital.

I have made this digression here because the nature of X-ray analysis is so well exemplified by Mrs. Hodgkin's work. Her success in analysing penicillin is a natural sequel to earlier triumphs, such as the solution of cholesteryl iodide which verified the nature of a typical sterol complex. She is a leading expert in the most difficult kind of pure crystal analysis, establishing the shape of very complex and unsymmetrical molecules. It is fair to claim, I think, that our country has almost a monopoly of this art in its highest form, and I would like to refer to a few other cases which to me are outstanding examples. One of these is Jeffrey's analysis of geranylamine hydrochloride. Some may wonder why a structure with so exotic a name was considered of high importance, but the point is that it has elements of isoprene linked together, and rubber is polymerised isoprene. This intense study of two joined links of a rubber chain may well cast a flood of light on the general nature of rubber-like bodies. Another recent example is the solution of a sucrose compound by Beevers and Cochran. The sugars form very unsymmetrical molecules; in this case a sixfold and a fivefold ring are joined together and the bond lengths and bond angles have been determined. I always find an elegance in the method of attack on such complexes which is aesthetically satisfying. The solution seems so obviously right once it has been found, and explains so much.

Beevers is in charge of the Dewar Crystallographic Laboratory in Edin-

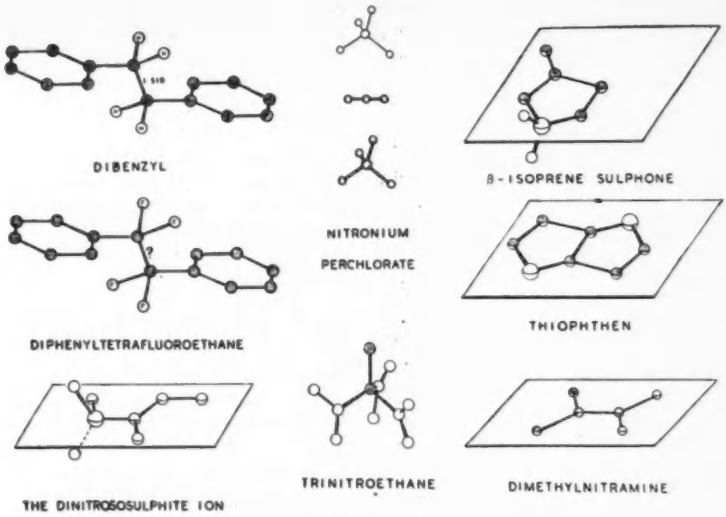
burgh, another centre where highly complex molecules are being analysed like the sucrose molecule mentioned above. His earlier work was largely on water of crystallisation and the structure of complex hydrates generally. At present J. H. Robertson, in his laboratory, is making an attack on the alkaloids. The structure of strychnine is still not known with complete certainty, although it has been studied so intensively by the organic chemists. The workers in the Dewar Laboratory have made considerable progress with compounds of strychnine and brucine; it will be a very real triumph if their exact configurations are determined by X-ray analysis.

Exact Measurements

In another side to the work on organic compounds the emphasis is upon the accurate determination of atomic positions. Robertson at Glasgow has been making a systematic examination of relatively simple molecules in which the chemist already knows the relative position of all the atoms, his object being to translate such 'chemically known' structures into terms of exact bond-lengths and valency angles, and correlate them with valency theory. He has determined the carbon-carbon distances in a number of molecules, showing that there are many intermediate stages between the standard single, double and treble bonds. He is now engaged in a three-dimensional analysis of naphthalene and anthracene, the two structures which were analysed by my father some twenty-five years ago and were the first organic compounds ever to be determined. He is examining long saturated CH_2 chains in a series of dicarboxylic acids and finding an alternation of long and short bonds. He is also examining long sulphur chains in polysulphides and polythionates.

Another centre where both new structures and bond lengths of known structures are being examined is Cox's laboratory in the Chemistry Department at Leeds. Professor Cox has kindly supplied me with a composite diagram which enables one to see the scope of his recent work at a glance. In diphenyl and the related compound where hydrogens are replaced by fluorine, the interest lies in the nature of the central bond. It is shorter than the 1·54 Å characteristic of a carbon-carbon single bond in diphenyl, and Cox is studying the effect of the fluorine atoms in an attempt to discover the nature of the bond. Nitronium perchlorate is a compound in which $(NO_2)^+$ plays the part of a positive ion, as has been deduced by Ingold on chemical evidence. The analysis of $K_2SO_3 . 2NO$ establishes the nature of the negative ion; chemists have speculated about the structure of this compound for the last hundred years. According to the classical stereochemistry of nitrogen, the N—N bond in dimethyl tetramine should be of the normal single type; it proves to be 1·26 Å in length instead of 1·40 Å which is characteristic of a single bond, and to be coplanar with other bonds to the nitrogen atom, so it has more of a double-bond character. The other figures show interesting heterocyclic compounds.

Powell at Oxford has an X-ray centre which collaborates closely with the chemists. One interesting line of work has been on complex intermolecular



▶ STRUCTURE DETERMINATIONS *done in the Chemistry Department, University of Leeds, by Prof. E. G. Cox. The shaded atoms are carbon.*

compounds, for instance that of iodo-aniline with trinitrobenzene. A similar line of work has been developed in James's laboratory at Cape Town University. In Powell's compounds the two large molecules are of such a shape that they conveniently pack together in equal proportions. James has studied more complex cases, in which each type of molecule is stacked in rods, and the rods are packed side by side. The repeat distance may not be the same for each kind of rod, so that there is no simple ratio between the number of molecules of each kind, and very complex and beautiful X-ray diffraction effects are produced. Perhaps the most striking of Powell's recent analyses has been that of substances which he calls 'clathrates'. Quinol molecules link together to form two systems of inter-penetrating networks. Each is like a wire-netting structure in three dimensions, continuous in space but not bonded to the other though interwoven with it. There are large open spaces in the meshes, and gas molecules act as 'fillers' to occupy these spaces and stiffen the two networks relatively to each other. It has long been a mystery how such molecules as SO_2 could be bound by quinol so firmly that the whole structure had to be destroyed before they could be released. They are now seen to be very loosely held chemically, but completely caged in physically.

We have at Cambridge a group working on organic chemical prob-

lems, in which Cochran is the leader. Pyrimidines and purines are being analysed, as primary building stones in the nucleic acids. This group works closely with Professor Todd and his chemists.

The investigations described in the last two paragraphs are essentially part of an enquiry into the physical basis of the chemical molecule, an attempt to understand its dynamics more completely by discovering the relative positions of its atoms. The examples I have given, to which many more could be added, come under the head of 'chemical crystallography'.

Minerals

The forms of matter which come under the heading of 'minerals' are an interesting group. The essential property of a mineral is stability; in other words its atoms are arranged in such proportions and positions that a minimum of potential energy is attained lower than that of any alternative grouping. Hence arise both the limited numbers of minerals, and the very rigid geometrical laws which their structures obey. The deducing of the structural relationships in the mineral kingdom, particularly those in the silicates, has been one of the triumphs of X-ray analysis. The broad outlines of the scheme are now clear, but there are several fascinating lines of work to pursue.

The work which is being carried out at the British Museum of Natural History by F. A. Bannister is an excellent example of the use of X-ray methods. Mineralogists have collected and named varieties from all parts of the globe. There is so much isomorphous replacement in minerals that composition is often an uncertain guide to the identity of a specimen. It is very interesting to note, now that we know more about internal structure, how right the mineralogists have been in allowing themselves to be guided by external form rather than composition in classifying their mineral species and families. But many minerals are in a microcrystalline state where external form is of no assistance. Bannister is carrying out a planned programme of mineral examination, which is leading to improved identification and classification. New minerals are being discovered which were previously unsuspected constituents of specimens, and minerals to which different names had been assigned are being shown to be of similar structure. Since X-rays readily tell us the number of atoms in each unit of pattern, formulae can be rewritten with far more certainty.

The felspars are the most important constituents of the earth's crust, and are outstanding in their importance to petrologists who study the history of rock formations. They vary in composition and symmetry, but their external form shows that they are closely related. W. H. Taylor first established their structure, showing that they are all based on the same characteristic pattern. Typical formulae are $KAl_3Si_3O_8$, $NaAl_3Si_3O_8$, $CaAl_2Si_2O_8$. The aluminium and silicon atoms form with the oxygens a continuous framework of tetrahedra, in the meshes of which the other ions are incorporated. But although the same structural type is common to them all, they are rich in variety and there are many fascinating differences of second order in their structures and properties. Minerals of the same composition may have

different optical properties and even different symmetry, and these differences are related to the history and mode of formation of the rock in which they appear. Taylor is now trying to study these finer details. Why does a pure potash felspar appear sometimes to be monoclinic in symmetry, and sometimes triclinic? What is the cause of the irreversible change in optical properties which some specimens undergo on heating? How do the structures fit together in felspars which are alternate slices of potassium and sodium felspar? Finally, what is the structure of the intermediate forms between $NaAlSi_3O_8$ (albite) and $CaAl_2Si_2O_8$ (amorthite)? This last is a very intriguing problem. The series has always been regarded as a typical case of simple isomorphous substitution, but X-ray diffraction shows that it is really a very complex phenomenon. Extra diffraction spots show that larger-scale repeats are superimposed on the simple felspar pattern, in a way which depends on the proportions of sodium and calcium. The problem is interesting for its own sake as an example of X-ray optics, but also important because we wish to understand what conditions have produced these variations in the rocks.

Finally I must refer to the work on clay minerals which G. W. Brindley is doing at Leeds. Clays are composed of minute spangles of mineral, tiny sheets of mica-like structure which are often polar in their nature. One face of the sheet is different to the other, they have 'bread' and 'butter' sides, and it is probably this polar nature which prevents their crystallising on a large scale owing to their tendency to curl and warp. These sheets form, as it were, the experimental benches on which the chemical operations in the soil are carried out. Nothing could be of more importance to soil chemistry than a knowledge of the structures of the clay minerals and their related species.

Structure of Metals

Passing now to the structure of metals, we may conveniently distinguish between two fields of investigation. On the one hand, there is what may be called 'metal chemistry,' the physical basis for the types of structure formed by metal atoms in various proportions; on the other hand, there is the study of what may be called the 'physical geography' of metallic aggregates. By this last is meant the size and orientation of the crystallites in a metal, their strains and structural distortions, incipient segregations into different phases such as take place in age-hardening, and exchanges of atomic position such as take place in the order-disorder change. The physical properties of a metal or alloy are much influenced by these characters. On both sides, X-ray analysis has made contributions of really vital importance.

I think it may be fairly claimed that alloy chemistry had no rational basis until structures were determined by X-rays. There is an interesting difference in character between a metallic compound and other kinds of chemical compound. One can, of course, find examples of all intermediate stages, but we are concerned here with broad generalisations. A typical metal compound is composed

of markedly electropositive atoms. It follows, as a consequence of the dynamics of such a structure, that wide variations in composition of any one alloy 'phase' are possible. In an extreme case, such as copper and gold, all proportions can unite to form a single structure. This is in complete antithesis to the relationship between sodium and chlorine, for example, when we find pure sodium, pure chlorine, or sodium chloride with the exact stoichiometrical relationship represented by the formula NaCl. To call the former a case of solid solution and the latter a true chemical compound takes us no further in explaining the physical basis of the difference. We may perhaps express the nature of an alloy by saying that different possible arrangements of the metal atoms, or different phases, are separated by fine second-order differences in their potential energy so that very little tips the structure in one direction or another. A compound such as NaCl is at the bottom of a deep narrow pit of potential energy, and the slightest variation in composition increases the energy greatly. An alloy is at the lowest point of a very shallow bowl with many alternative bowls open to it whose bottoms are nearly at the same level. What is equally important is that metal atoms are very mobile and readily exchange positions, and as a consequence these finer differences have an opportunity to be effective. Hence arises the rich variety of changes that can take place in an alloy system, and the great influence upon it of its thermal or other history.

Fuels From Atmospheric Nitrogen

➤NITROGEN from the air, which makes up four-fifths of what we take into our lungs at every breath, is a raw material from which fuels to supplement petroleum products will be made, particularly for special uses.

Certain nitrogen compounds, including ammonia and hydrazine, are actively being considered as fuels, the American Chemical Society was told by L. F. Audrieth of the University of Illinois. The Germans, he said, experimented successfully with hydrazine to power submarines during the war. Concentrated ammonia, not the weak household solution, is already being used as fuel.

Nitrogen is one of the few inexhaustible raw materials since it is the major ingredient of the earth's atmosphere. This nitrogen is now being converted into useful chemicals by several processes. The most important of these is one by which the nitrogen is combined with hydrogen to form ammonia. From this ammonia many other nitrogen compounds can be made.

Among the newest of the basic nitrogen chemicals are hydrazine and hydroxylamine, both of which were largely laboratory curiosities ten years ago. Today, both are being produced in substantial quantities and new industrial uses are being found for them.

Hydrazine is a watery liquid which makes an excellent fuel because it burns with a hot flame and gives off no toxic gases. A chemist might call it an analogue of hydrogen peroxide. It is similar in make-up but contains nitrogen instead of oxygen.

Chemical Patents This Month

To obtain copies of patent specifications, order by number from the U. S. Commissioner of Patents, Washington 25, D. C., enclosing 25 cents (currency or money order, not stamps) for each patent ordered.

➤ STARTING a fire at the bottom of an oil well may sound at first blush like walking into a powder magazine with a lighted cigar. Yet this is precisely what a California oil man, Ralph M. Steffen of North Hollywood, proposes to do in order to heat the oil-bearing sand and speed up flow in low-yield or nearly exhausted wells. Actually it is safe enough, for air would have to be piped down the bore-hole to keep the fire going; so would the fuel—presumably natural gas.

U. S. patents 2,444,754 to 2,444,756 have been issued on this method. In the simplest form of the method, gas and air would be piped down separately and burned together at the bottom. In a more elaborate form, the two would be mixed in a cylinder with a piston, which would function as an internal-combustion engine to drive a second, directly-connected piston of a pump to raise the oil. Heat of the exhaust would still warm up the sand and hasten the sluggish flow.

Plastic Telescope Mirrors

➤ QUANTITY production of precision mirrors for Schmidt-type and other reflecting telescopes at greatly reduced cost is promised by the manufacturing method on which patent 2,444,532 has been granted to John H. Richardson of Needham, Mass., assignor to the Polaroid Corporation.

A thermosetting synthetic plastic is the material used, instead of the conventional glass. A correctly figured metal master mold must first be prepared. This is coated with the fluid plastic, then heated in an oven until it has partly set. A base of plaster or other rigid material is then added, and the whole returned to the oven to complete the thermosetting process. Then the finished mirror is detached from the mold for silvering.

Organic Acid Recovery

➤ A STEAM-DISTILLATION method for salvaging acetic, propionic, butyric and other industrially useful acids from fermented garbage and sour sewage sludge is covered by patent 2,444,527, issued to R. D. Pomeroy of Altadena, Calif. The foul-smelling liquids trickle over a series of baffles under a partial vacuum, while the steam acts on them.

Wood-Waste into Money

➤ PENTOSANS and hexosans, two of the soluble carbohydrate-like compounds in the liquid wastes from wood-processing plants that make a lot of trouble when poured into rivers, are saved as industrial raw materials in the process on which H. E. Hall of Lyle, Tenn., and L. L. Coleman of Wilmington, Del., have received pat-

ent 2,444,823. The pentosans are converted into pentose sugars by the action of an enzyme from a common black mold, *Aspergillus niger*. The hexosans are precipitated out by the addition of acetone or a mixture of acetone and an ether or an alcohol. Patent rights are assigned to the Masonite Corporation.

Catalyst Pads

➤ FINELY DIVIDED platinum intended for catalyst purposes is incorporated into wet asbestos fibers, in the process on which patent 2,444,896 was granted to L. L. Shreir of London, England, assignor to Baker and Company, Inc., of Newark, N. J. The fibers are formed into compact pads by draining the wet mass in a screen-bottomed trough.

New Use for Air

➤ MOLTEN GLASS is formed into continuous sheets or strips, in the invention of M. L. Devol of Wilkinsburg, Pa., by passing it between rollers, which are prevented from sticking to the hot melt by thin films of air, kept continuously blowing between them and the glass. Patent 2,444,731, issued on this invention, has been assigned to the Pittsburgh Plate Glass Company.

Virus Vaccine Patents

➤ A NEW PROCESS for producing vaccines against virus diseases is covered by two patents by Dr. Leslie A. Chambers, University of Pennsylvania biochemist. Basic protein precipitants, such as those obtained from fish sperm, are added to culture material in which the virus has been grown, and the resultant material from their reaction is then purified and attenuated into vaccine by chemical or physical treatment.

The first patent, No. 2,445,300, is on vaccines against such diseases as equine encephalitis, yellow fever and rabies; the second, No. 2,445,301, is specifically against influenza. Rights in both are assigned to the trustees of the University of Pennsylvania.

British Weed Killer

➤ A CHEMICAL relative of 2,4-D, which might be called 2,4,5-T because its full name is 2,4,5-trichlorophenyl acetic acid, is the newest of weed-killers. Its use for that purpose is protected by patent 2,444,905, issued to an English chemist, Wilfred A. Sexton, of Manchester, assignor to Imperial Chemical Industries, Ltd.

Industrial Improvement

➤ SULFUR DIOXIDE, used industrially in vast quantities, is prepared by an improved process on which patent 2,445,112 has been granted to W. T. Grace of Upper Darby, Pa., and J. C. Muller, Jr., of Little Falls, N.J., assignors to E. I. du Pont de Nemours and Company. The molten sulfur is vaporized as it flows over a sloping surface instead of in a flat pan, thus avoiding interruption of the process by accumulation of scum on the top and ash at the bottom.

Discriminating Geiger

➤ DETECTION of penetrating radiations such as X-rays or gamma rays in various industrial processes like oil prospecting, is put on a more highly discriminating basis by a new-type Geiger tube invented by F. P. Hochgesang of Woodbury, N. J. Instead of having only one chamber the tube is divided into a series of concentric chambers by means of tubes of shield-

ing material, with a circuit to register penetrations of each tube. This gives a spectrum of the radiation, with the "hardest" rays reaching the center. Rights in the patent, No. 2,445,305, are assigned to the Socony-Vacuum Oil Company.

Light-Polarizing Sheet

➤ THREE PATENTS, all assigned to the Polaroid Corporation, Cambridge, Mass., have been issued on variants of a light-polarizing sheeting in which the stretched polyvinyl molecules of the sheeting itself do the job of filtering out the similarly-oriented light waves. Boric acid accomplishes the necessary cross-linking of the molecules, in the method on which Frederick J. Binda received patent 2,445,555. Iodine is added to the boric acid in patents 2,445,579, issued to Mark Hyman, Jr., and Cutler D. West, and 2,445,581, granted to Dr. Edwin H. Land, founder of the Polaroid Corporation.

Two Sea-Water Purifiers

➤ REMOVING SALT and magnesium chloride from sea water to make it potable is the objective of the process developed by Prof. Alexander Goetz of the California Institute of Technology. This is accomplished chemically by adding silver oxide to precipitate chlorine ions in insoluble form, a zeolite to bind the sodium, and barium hydroxide to remove the magnesium. The process was awarded patent 2,445,669.

The rival process for emergency production of potable water out of sea water is represented in patent 2,445,350, obtained by D. C. Ginnings of Macomb, Ill., on a multiple-effect solar still. A wick draws up sea water, and solar radiation falling on a black film supplies heat for its evaporation. The vapor is condensed into good, non-salty water in a separate compartment and siphoned into a storage pocket.

X-Ray Mold for Penicillin

➤ PENICILLIN production can be greatly increased through treatment of the molds that produce it with X-rays. This is disclosed in newly-issued U. S. patent 2,445,748, taken out by Dr. M. Demerec, head of the genetics department of the Carnegie Institution of Washington, whose laboratory is at Cold Spring Harbor, N. Y.

X-ray doses of from 50,000 to 150,000 roentgen units are applied to mold spores. Most of them are killed, but among the survivors are newly induced, mutated strains which produce larger "crops" of penicillin than those currently in use. The same technique can be applied to other molds producing other compounds, states Dr. Demerec, and if desired atomic fission radiations and even cosmic rays may by employed instead of X-rays.

Since Dr. Demerec's discovery was made in the course of federally supported wartime research, the patent is assigned to the government.

High-Purity Thorium

➤ THE RARE element thorium is produced in metallic form of a high degree of purity (above 99.5%) by a new process on which three Westinghouse researchers, Dr. H. C. Rentschler, W. C. Lilliendahl and J. E. Gray, have received patent 2,446,062. Rights are assigned to the Westinghouse Electric Corporation.

Thorium oxide is mixed with metallic calcium in a molybdenum cup. This is placed under a high-silica glass bell-jar, the air exhausted and the inactive gas argon substituted. Then a high frequency coil around the outside of the bell-jar induces high temperature within the cup, bringing about the conversion of the calcium into calcium oxide and the freeing of the thorium as practically pure metal, in powder form.

After an acid wash to remove the calcium oxide, the thorium powder is first formed into pellets under a pressure of 20 tons per square inch, then sintered. These blocks of sintered thorium can be cold-worked into wire, sheets or any form. This new process can be conducted entirely under glass, and hence offers better possibilities of observation and control than the one which it replaces, in which the thorium oxide-calcium mixture was heated in a massive iron bomb.

Selenium "Wool"

➤ THE "MOON ELEMENT," selenium, used in electric current rectifiers and photocells, is produced in a new fibrous form similar to glass wool by a process on which an English inventor, D. L. A. Driver of London, has been granted patent 2,445,768. The molten selenium is sprayed through a series of nozzles into a chamber, where it forms a felted mat of "wool" on a moving belt. This mat can be rolled for storage, or immediately cut into disks for use in rectifiers or photocells. Rights in the patent are assigned to Standard Telephone and Cables, Ltd.

Sea Weed and Ice Cream

➤ AN ICE-CREAM stabilizer made from seaweed is the invention of a coast-of-Maine man, V. C. E. Le Gloahec of Rockland, on which he has received patent 2,445,750. It is a complex alginate of calcium and sodium or potassium; alginic acid comes from seaweeds, which are algae.

Wrinkle-Resisting Cottons

➤ ALL TYPES of cotton will soon be available that withstand summer wear without wrinkling because treated with a new finish which also controls shrinkage to a low limit. The finish will be known as Superset, a product of the American Cyanamid Co.

Wrinkle-resistant finishes have been widely used for rayon fabrics but up until now only heavy cotton could be treated with them because they seriously weaken the fabric. The new material causes little or no loss of tensile strength. The finish is effective after many severe test washings.

Melamine resin forms the basis of the new preparation. It has been modified in such a way that it does not affect the strength of the fabric. It is applied in the mills, and has been successfully tested in use with ginghams, dress goods, prints, denims, corduroys, seersuckers and other types of cotton garment material.

The vast eruptions on the sun, constantly sending flaming masses of matter farther up than the distance from the earth to the moon, are believed to be due to atomic energy.

Elements in the Heavens Tell Age of Universe

Cosmic Chemistry

➤ URANIUM, the atomic bomb element, is undoubtedly present in the sun and stars, but there is no danger or likelihood that it will explode.

The International Astronomical Union meeting in Zurich learned that changes in the heavier elements were completed when the universe was young. While vast atomic energy is manufactured from hydrogen, power from uranium is not possible under the conditions of the sun.

Long before the stars were formed, the universe may have been in a state of temperature and density which favored the nuclear reactions required to produce the abundances of the heavier elements, Prof. O. Klein of Stockholm's Technological Institute told the astronomers.

Then, as the stars came into being, the abundances of the heavy elements became "frozen." There exist no nuclear processes which can operate under the present properties of stellar material and appreciably change the abundances of the heavy elements. Only the lighter elements continue their metamorphosis.

Hydrogen Most Abundant

Hydrogen is by far the most abundant element in the stars. For every atom of any metal there are about six atoms of carbon, nitrogen and oxygen; 500 atoms of helium; and 5,000 of hydrogen, Dr. A. Unsold of the University of Kiel, Germany, reported at the meeting.

Although we see only the outer layers of a star, we still have a pretty good idea of its total composition. Violent convective currents within the stars keep them constantly stirred up, stated Dr. F. Hoyle of the University of Cambridge, England. Thus the composition of the outer layers, which we observe, is the same as that of the interiors, where the nuclear processes take place.

Space Matter Like Stars

Space and the stars that shine are much the same, except that the matter in the stars is close together.

This finding reported by Prof. Bengt Stromgren of the University of Copenhagen Observatory helps support some of the latest American theories as to how the stars were formed in the beginning.

Stars were formed out of space material. That is a part of the theory of Prof. Lyman Spitzer, Jr., of Princeton, that atoms in space stick together to form bits of matter. Prof. Fred Whipple of Harvard carried the idea further, showing how the stars and planets were formed.

A chunk of interstellar space the size of a big room contains about 10,000,000 atoms of hydrogen, 60 atoms of sodium, 100 atoms of calcium, four of potassium, and two of titanium, Prof. Stromgren reported.

Although we do not yet know how abundant helium is, about a million atoms of it may be present. All the

other elements are also represented, being about as abundant as in normal stars.

Flaming Youth of Stars

In the heavens there are spendthrift stars that in their youth are very brilliant and enormously hot. But these stars soon use up their atomic fuel and disappear from sight.

Tau Scorpii, so hot on the surface it reaches a temperature of 20,000 degrees Centigrade, and similar hot stars generate energy at a prodigious rate during their short but fiery lives of less than 3,000,000,000 years. But much of their hydrogen (astronomical atomic fuel) is soon converted into helium.

As they grow old, they contain little hydrogen and disappear from sight, at least as hot, blue (B-type) stars, Prof. Henry Norris Russell, famed astrophysicist of Princeton University, reported to the International Astronomical Union.

Prof. Russell's communication was delivered by Dr. Otto Struve, of the Yerkes and McDonald Observatories of the Universities of Chicago and Texas, as chairman of the symposium on the chemical composition of the universe. He, like many astronomers present, was surprised to hear from Dr. A. Unsold of the University of Kiel, Germany, that the sun, stars and other bright bodies in the heavens have not changed much since they were created.

Even such hot stars as Tau Scorpii, Dr. Unsold found, have kept pretty much their original composition.

There is little difficulty in seeing why nebulae and the matter between the stars have undergone little change. They lack the mechanism which converts hydrogen into helium by means of the famous "carbon cycle," first proposed by Dr. Hans A. Bethe of Cornell University.

The sun and normal cool stars generate energy at such a slow rate that, during their lifetime, they cannot have converted a large amount of hydrogen into helium. Now astronomers are told that hot stars such as we now see in the sky also have changed little in their lifetime.

Early Life of the Cosmos

➤ WHEN THE UNIVERSE was a tenth as old as it is now, the great masses of stars called the galaxies (like our Milky Way) were formed.

It took that time, 300,000,000 years, from the beginning of things for the universe to evolve into the general shape that it now is.

This new view of the past of the cosmos has been figured out by Dr. George Gamow, mathematical physicist of the George Washington University, Washington, D. C., author of *Biography of the Earth* and other books.

He has figured it out quite literally, for the formulae that he derives to express the size and mass of the galaxies are written in the simple and elemental terms of the properties of the elementary atomic nuclei (hearts of matter.)

A few months ago Dr. Gamow joined in fixing the original temperature and density of the expanding universe when it was a few minutes old. In the beginning, all creation was a highly compressed gas made up of neutrons (now best known as the trigger of atomic bomb fission.)

This gas (heavy as iron) started decaying into protons and electrons and building up the heavier chemical elements. The stuff of the universe was completely made in about one hour.

This probing into the origin of the universe is called by Dr. Gamow "alpha, beta, gamma" stuff because it was done by a team of R. A. Alpher, who got his Ph.D. for it, Dr. H. Bethe, the Cornell physicist famous for the atomic energy theory that keeps the sun stoked, and Dr. Gamow.

Now Dr. Gamow is following the expansion of the universe further. Starting with these initial conditions and the correct proportion of the various kinds of atoms that were "cooked" at the beginning, he finds that the size and mass of the great clouds of stars can be calculated from the initial conditions. And since the universe got into its essentially present shape, nine times as much time has elapsed as was necessary to create the galaxies.

"I am quite excited about these results on the evolution of the universe," Dr. Gamow told Science Service. "It seems to be the best piece of work I have done since the theory of radioactive decay 20 years ago."

Dr. Gamow was lecturing during the summer at Ohio State University. He got the idea for his new researches on the universe while visiting the giant telescopes on Mt. Palomar and Mt. Wilson, and he developed the new theory while riding back east on the Super-chief.

In the complex formulae that show the relation between the microcosmos of the atomic nuclei and the macrocosmos of the stellar galaxies, Dr. Gamow uses the elementary charge, the quantum constant, the mass of the proton, the velocity of light, Newton's gravitational constant, and the binding energy of the deuteron. From these he derives the diameter of the stellar galaxies as 12,000 light years and the mass of the galaxies as 15,000,000 times that of the mass of the sun. This corresponds roughly with the dimensions and mass that the astronomers find for some of the galaxies, although the Milky Way in which we live is a giant and considerably larger.

A preliminary communication on his theory has been sent by Dr. Gamow to the *Physical Review*, journal of the American Physical Society, and a longer account to *Nature* (London).

Meteorites' Parent Planet

➤ THE ANCIENT PLANET, from which were broken all meteorites found on the earth today, was born less than 60,000,000 years ago.

This finding, which reduces the relative age of the parent planet from a top limit of some 7,600,000,000 years to a mere 60,000,000 years, is reported by Dr. Carl August Bauer of the University of Michigan in the *Physical Review*.

Smaller than the earth, this now-disrupted planet once moved in an orbit between those of Mars and Jupiter, where the asteroids or minor planets are found today.

This upper limit on the age of the planet can be established because the uranium and thorium contents of the meteorites he studied are sufficient to produce all of its helium in only 60,000,000 years.

Cosmic radiation thus produces helium in meteorites 70 times faster than he had previously predicted, Dr. Bauer explains. This is true because, to agree with his new findings, cosmic radiation has to produce the helium in 60,000,000 years rather than in 4,000,000,000 years, as previously estimated.

This high rate of production of helium in meteorites, as compared to the calculated rate just outside the earth's atmosphere, may arise from the effect of the sun's general magnetic field, as suggested previously, or from secondary helium-producing processes that have not been considered, Dr. Bauer reports.

The new findings overcome two difficulties:

1. Difference in the helium content of different fragments of the same meteorite.

2. Difference from point to point within the same fragment.

Five Bethany meteorites, all located in a limited region of Great Namaqueland, Southwest Africa, upon examination were found to be similar in structure and composition. But one has been assigned to a different meteorite fall because its helium content is so much greater than the others.

This difference can be more satisfactorily accounted for by assuming that the helium was produced by cosmic radiation, Dr. Bauer explains. In this manner the difference in the helium contents of the various fragments would arise from the difference in their location within the original pre-atmospheric mass.

It was Dr. Bauer who last fall announced that iron meteorites arriving from outer space are not seven billion years old, as previously estimated, but only about half that age.

At that time he pointed out that meteorites could be "artificially aged," extremely small amounts of helium gas contained in the bits of heavenly iron resulting from intense cosmic-ray bombardment in outer space. Heretofore it has been assumed that the helium was due to radioactive breakdown of uranium and thorium, the iron fragments having been in existence long enough as solids to allow the helium gas in them to be formed that way.

If cosmic radiation produced helium in small meteorites, the University of Michigan scientist reasons, then this process is sufficient to produce, in the same period of time, all the helium observed in any meteorite.

Cosmic Rays From Stars

➤ COSMIC RAYS, created in the atmospheres of certain stars whose magnetic field fluctuates violently, are shot forth periodically from these stars.

This latest theory of the birth of cosmic rays is advanced by Dr. Horace W. Babcock of Mount Wilson Observatory of the Carnegie Institution of Washington.

The random directions from which cosmic rays approach the earth would thus be explained, Dr. Babcock points out. He has sent a scientific report of his new theory to the *Physical Review*.

The number and distribution of magnetically active stars is not yet definitely known, but they are probably fairly numerous throughout the disk-shaped galaxy.

It was Dr. Babcock's continued

study of the peculiar star HD 125248 that led him to picture such stars as ejecting cosmic rays. In this star, the polar magnetic field regularly changes from plus 7,800 gauss to minus 6,500 gauss, and back, in 9.295 days.

The star's alternating magnetic field suggests that at certain phases the suppressing effect of space charge that tends to keep cosmic rays close to the star will be eliminated. Periodically positive ions and electrons, Dr. Babcock reasons, are ejected alternately from the polar regions of the star at certain phases of each magnetic cycle.

Lines in the star's spectrum change in intensity as indicators of the changing magnetic cycle. The width of the europium lines, for instance, is greatest when the star's magnetic field reaches maximum; the chromium lines are widest when the greatest negative magnetic intensity is attained.

About a score of these peculiar variable stars, brighter than the sixth magnitude and thus visible to the naked eye, are known. All are suspected to have varying magnetic fields. But these magnetic variations are more fundamental than the mere changes in line intensity would indicate, the Mount Wilson astronomer says.

Electronic Calculators

➤ FAST ELECTRONIC calculators will soon begin to ease somewhat the laborious work of astronomers by extremely rapid solution of some of the complex numerical problems that have plagued them in the past.

Dr. John B. Irwin of the University of Pennsylvania's Flower Observatory listed at the meeting some of the astronomical problems to be solved by the EDVAC, the Electronic Discrete Variable Computer which will go to work at the University's Moore School of Engineering following a period of testing this summer and fall. He mentioned specifically:

Preliminary computation of the orbit of an asteroid or a newly discovered comet.

Solution of equations concerning eclipsing double stars.

Calculation of the position of stars and their motions from catalogue-type photographs.

Study of stellar statistics and motions.

Reduction of data from the measurement of stellar motions by their spectra.

To emphasize the speed of the machine, Dr. Irwin stated that only about 75 seconds will be needed to get the preliminary orbital elements, make corrections, and run out a short list of predicted future positions.

The intense heat in a gas turbine, too varied for accurate measurement until now, may be determined by a chrome cobalt alloy which reveals temperature by change in its color.

Siam, ranking fourth in world tin production, produces also some iron, tungsten, antimony, lead, gold and gems, notably sapphires.

Exploding Atoms Are a Hope Of Science in War on Cancer

Science Fights Disease With Isotopes

➤ EXPLODING ATOMS are among science's greatest hopes today in the fight against cancer.

Just as radium and the surgeon's knife can be used to destroy some malignant tissue that is cancer, so radioactive elements resulting from the processes of the atomic bomb can be used to wipe out some malignant growths.

Iodine, gold and cobalt in radioactive forms are the most promising of the potential anti-cancer radioisotopes.

No scientist would be foolhardy enough—or cruel enough to cancer victims—to hold out too much hope in individual cases. Nevertheless, the years of human life to be saved by future applications of radioisotopes promise to compensate many times over the loss of human life due to use of the atomic bomb in warfare—if the world can arrange not to use the atomic bomb as a weapon in the future.

With Iodine

When the cancer is in the thyroid gland, radioiodine is used as a means of diagnosis and often as treatment. The thyroid gland picks up and utilizes nearly all of the iodine in the human system, normally about 80 times as much as any other tissue.

When the uranium atom fissions, as it does in the atomic bomb and in the more peaceful chain-reacting uranium pile, one of the many elements formed is iodine with a weight 131 times the mass of the hydrogen atom. This special fission-made iodine gives off powerful gamma rays, like radium.

It can therefore destroy human tissue if it can get at it. Since it is attracted to thyroid tissue, it can be used to destroy it, whether or not it is diseased. Separate out this particular kind of iodine from all the many products of uranium fission as the Atomic Energy Commission does at Oak Ridge, Tenn., feed it to the patient and the radioiodine will go to the thyroid and do its work. Fortunately, this kind of radioiodine is relatively short-lived, half of it losing its activity in eight days. So it is relatively safe to use, since it will not go on with its lethal bombardments when they are no longer needed.

For treating over-active thyroid glands, a condition known as toxic goiter, radioiodine has been very successful. The Mayo Clinic reports success in 80% of the cases treated. Radioiodine also helps to diagnose the disordered thyroid, whether it is overactive, underactive or cancerous. It is also used as a tracer to locate the deposits of thyroid cancer tissue in various parts of the body far removed from the parent growth—metastases they are called.

The results of treatment of thyroid cancer with radioiodine have not been nearly as satisfying as the treatment of toxic goiter. The latest report of

the Atomic Energy Commission explains that malignant thyroid tissue often does not pick up as much of the radioactive iodine as does the normal thyroid tissue. Much research is underway, some of it very promising, particularly attempts to put the radioiodine in organic compounds that will be selectively absorbed by cancerous tissues.

At the Sloan-Kettering Institute for Cancer Research in New York, animal experiments are testing whether natural antibodies can be made to carry radioiodine to special parts of the body, such as the liver and kidney, there to administer strong doses of radioactivity.

With Other Elements

The metal cobalt when irradiated in the Oak Ridge pile emits radiations similar to those of radium. Since it can be made inexpensively and fabricated into special applicators, it will come into general use for cancer treatment when handling and dosage are worked out.

The radioactive form of phosphorus is being used to treat leukemia, a cancerous condition of an excess of white corpuscles in the blood, and results are as effective as X-ray therapy without causing uncomfortable radiation sickness. This use is based upon the fact that phosphorus concentrates in the blood-producing centers.

Treatment of cancer by radioisotopes is still in its early stages. Much more must be learned about basic bodily processes generally, and specifically what molecules concentrate in diseased body tissues and can therefore carry to them the exploding atoms that can blast out the disease.

Science has had ample supplies of radioisotopes for only a short time as scientific progress goes. The first shipment of radioisotope was made from Oak Ridge just two years ago. It was radiocarbon 14, a substance that Massachusetts General Hospital research hints may be absorbed rapidly by diseased tissue when it is incorporated in protein compounds.

With Neutrons

Neutrons, the fundamental atomic particles which are so important in fission, have turned out to be less effective in the treatment of cancer than was once hoped.

Rather discouraging results from the only series of cancer patients treated with fast neutrons are reported by Dr. Robert S. Stone, of the University of California Medical School, in the *American Journal of Roentgenology and Radium Therapy*.

The radiologist said that the 249 incurable cancer patients in the series were treated after animal experiments showed the neutron beam from the cyclotron was highly destructive of cancer tissue, indicating that neutrons might help cancer victims who otherwise had no hope of survival.

A lack of any appreciable differentiation by neutrons on cancer and healthy tisue is given by Dr. Stone as the reason for the disappointing results.

Neutrons were effective in destroying cancer tissue, but Dr. Stone said that serious damaging after-effects also showed up some time after treatment. They were more severe than expected, there being no basis in

either X-ray therapy or animal experimentation with neutrons to expect such after-effects.

The five-year survival rate of the incurable patients treated with neutrons was 7.5%. If left untreated, the rate would have been somewhat less than 5%.

Eighteen patients were kept alive for more than five years. All of these patients had severe late reactions, some of them so severe that the patients were partially incapacitated.

However, Dr. Stone added that experimental work should be continued to determine if there is some way the cancer-destroying power of neutrons can eventually be applied.

With Phosphorus

Radioactive phosphorus from Oak Ridge is being used exclusively for the successful treatment of patients suffering from a blood disease called polycythemia vera at the University of Maryland Hospital in Baltimore, the Atomic Energy Commission revealed in its fourth semi-annual report to Congress.

In this disease, patients have too many red blood cells and in consequence their blood thickens, their spleens enlarge and they have the peculiar blue skin color termed cyanotic. The disease extends over many years with the patient growing weak, developing dropsy and heart and kidney trouble.

An attack on the cancer problem with radioactive calcium is being made at Georgetown University Medical School, in Washington D. C. This important bone-building element stays in the body longer and is more apt to go to bones and soft tissues when it is in oil-soluble form than when in water-soluble form, the Georgetown scientists have found. Several forms of cancer concentrate calcium, the AEC report of the Georgetown studies states.

Better knowledge of nerve disorders and of thyroid gland function in health and disease is likely as a result of studies with radioiodine and radioactive phosphorus at the Johns Hopkins University in Baltimore as summarized in the AEC report.

With Carbon

New light on resistance to specific germ diseases may come from other studies at this institution and at the National Institutes of Health, U.S. Public Health Service, Bethesda, Md. At Hopkins, radioactive carbon (C 14) has been successfully synthesized into an amino acid, arginine. This will be fed to mice in order to label the protein formed in the animals' blood serum.

The animals will then be immunized to some infectious disease and it is hoped the radioactive carbon will show whether the disease-fighting antibodies in their blood are composed of newly synthesized protein or of previously formed protein which has undergone rearrangement after the immunizing shots.

The Public Health Service studies on disease resistance center around use of radioactive carbon, phosphorus and arsenic in preparing radioactive antigens. The antigens are the substances in disease germs which call up disease-fighting antibodies in the blood.

Determining blood loss and blood needs of patients undergoing surgi-

cal operations may be done more quickly and accurately in the future, if preliminary work with radioactive phosphorus is borne out by further studies. This work, the AEC report states, is being done at the Medical College of Richmond, Va.

Several anesthetics block the entrance of radioactive phosphorus into the red blood cell, studies at the University of Virginia, at Charlottesville, show. This, the report states, "points to a possible general action of anesthetics and may aid in explaining the action of sleep-producing drugs."

Better knowledge of what vitamins do in the body may come from studies at Howard University, Washington, D.C., in which radioactive phosphorus is being used. At present the studies are concerned with learning how the vitamins affect the utilization of this important chemical in the chick embryo.

Radioactive Compounds

Latest peacetime service of the nation's atomic energy program is the sale of chemicals tagged with radioactive elements.

These chemicals are compounds, such as certain acids and alcohols, in which one of the elements is radioactive. The radioactive forms, called isotopes, of some chemical elements have been sold to researchers by the Atomic Energy Commission for two years. But the new tagged chemicals will speed studies where the radioactive elements are to be used in compounds.

One of the more important isotopes for research on living things, carbon with atomic weight of 14, is listed by the Commission as available now in several different compounds with more scheduled for production. Radioactive gold in the form of colloidal gold and aurothiosulphate is available for therapeutic use, it was announced.

Without Radioactivity

A radar research discovery during the war now makes it possible to trace chemical elements in some parts of the body without the use of hazardous radioactive isotopes.

The microwave spectroscope uses waves of the same length as radar to detect even tiny amounts of chemical elements.

Stable isotopes of elements, which differ only in atomic weight from the usual form of the element, can be fed to humans, animals or plants. The element may end up in the skin, hair or nails of an animal being tested, or in any part of a plant. It must be in some part that is detachable to be traced since the spectroscope can only be used on a small specimen. The part being tested is placed in the spectroscope where it will intercept microwaves and cancel out those frequencies corresponding to the isotopes of elements it contains.

Development of the microwave spectroscope is the result of work done at the Research Laboratory of Electronics of the Massachusetts Institute of Technology.

Radioactive isotopes which have been used to trace the distribution of elements and compounds in living organisms have a much wider range of uses than the stable isotopes. However, these isotopes are dangerous to life if given in too large amounts. Radioactivity poisoning, which causes

burns and in larger doses, disintegration of cells, might result.

Radioactive isotopes are also more expensive. They are used in such experiments because they can be traced with a Geiger-Muller counter.

Microwave research began during the war when scientists working on radar discovered that certain wavelengths used in radar were absorbed by gases in the atmosphere. At the Radiation Laboratory at M.I.T. and at Columbia University, projects were started to find out what gases interfered with what wavelengths. It was found that water vapor and oxygen absorb microwaves in such a way that they define the limits of usable radar waves.

After the war these discoveries led to work in the detection of gases by microwave spectroscopy and from there to the use of these waves in exploring matter.

Five Kinds of Atomic Bombs?

➤ AMERICA now has five different kinds of atomic bombs, the most modern of which tested at Eniwetok are presumably both more powerful and cheaper.

That is the best guess based on the official announcement that "tests involving three atomic weapons each of improved design" were successful in all respects and that results indicate very substantial progress.

The new tests did not, in all probability, involve any radically new and novel bombs, such as the hydrogen-helium bomb or the meson bomb about which there has been some speculation.

The stuff in them is basically the fissionable materials that we have been told about, uranium, plutonium and possibly kinds of uranium or other heavy elements made from thorium.

The Hiroshima atomic bomb was made of uranium 235 and the second bomb used on Nagasaki was made of plutonium, the synthetic element made in the atomic pile from the more common sort of uranium isotope 238. Similarly the new bombs are probably improved mixtures of fissionable elements or materials not used before.

Manufacture of bombs by new methods or further research upon new nuclear materials and methods is indicated by the portion of the statement that said "The President gave general approval of commission plans for steps it proposed to initiate at once for further nuclear development, based upon information gained from the tests."

This may indicate a different emphasis to atomic materials manufacture such as carried on at Hanford, Washington.

Everthing connected with a coconut palm tree is usable; leaves and trunk are used for houses, the husk around the nut shell yields a fiber, the milk is a cooling drink, the meat is food; when the meat is dried it becomes copra, a source of oil.

Motor Oil Has Been Improved, Synthetic Lubricants Are New

Check Your Oil

Reprinted from the Industrial Bulletin of Arthur D. Little, Inc.

MANY A MOTORIST still driving a prewar car considers lubricating oil the petroleum industry's most vital product. In fact, consumption of all lubricating oils in the United States has increased 54 per cent between 1939 and 1947. During this period, consumption of gasoline and tractor fuel increased only 43 per cent, and the number of vehicles registered only some 20 per cent. Growing lubricant consumption reflects the higher oil consumption of older cars, greater use of each car, the unprecedented increase in the number of trucks, tractors, and buses, and increased use in oiling industry's machines, which comprises nearly three-fifths of the current domestic consumption. The ratio of automotive motor oil use to gasoline consumption reached a peak in 1946, when there were few postwar cars. One petroleum economist has predicted that decline in this ratio, as newer cars predominate, will offset the increased use of cars, and consumption of automotive lubricating oil will be about the same through 1951.

Exports have risen by about 20 per cent since 1939. The United States is the primary world source of lubricants, and in 1947 exported over one quarter of its output, as compared with only five per cent of its gasoline.

From the user's viewpoint, motor oils have been greatly improved in the past several years, but the American Petroleum Institute still recommends the traditional 1000-mile oil change, on the grounds that dilution and contamination with dirt can be fully corrected only by replacing the oil. From the refiners' viewpoint, new processes have made many different types of crude oil usable.

An important part of refining is the removal from the raw lubricating stocks of asphaltic and other constituents which may form excessive amounts of carbon, varnish, or gum deposits in engines. In oils from some crudes, these materials constitute a relatively small per cent, and were formerly removed by filtration through clay. Others, containing higher concentrations, could be treated with sulfuric acid. During the past 15 years, methods have been developed for removing the asphaltic materials by use of solvents such as furfural (made from oat hulls) or phenol (carbolic acid), or other selective solvents. Wax, which may make the oil viscous when cold, can be removed by the analogous solvent processes.

There are a host of additives designed to improve particular properties of lubricating oils. Most widely used are "pour depressants," which retard wax crystallization and improve low-temperature fluidity. Oxidation and bearing corrosion inhibitors reduce engine deposits and prevent attack on certain bearing metals in severe service. Detergents

are used particularly for Diesel engines, in combination with oxidation inhibitors, to reduce ring gumming and hard carbon formation. They appear to act by keeping deposit-forming materials suspended or dispersed in the oil until they are removed by crankcase draining.

Other additives tend to keep oil thinner when cold and thicker when hot. Still others reduce friction and prevent abrasion, particularly on gears operating under extremely high pressures. An estimated 100 million to 200 million pounds of additives are used annually in lubricating oils at an average value of 15 to 20 cents a pound.

One new series of synthetic lubricants changes less in viscosity with temperature than most petroleum lubricants, and is unusually stable against high-temperature breakdown. These synthetics are more expensive than petroleum lubricants, and will probably be most used in heavy duty service in trucks, buses, and the like, where a premium is justified. The chief use now is in industry, where both water-soluble and water-insoluble types find special application, and as a hydraulic fluid.

Another new series of synthetic lubricants, known as silicone oils, is remarkable in its stability and the range of temperature over which it is suitably fluid. One of these fluids can be used at any temperature from 10°F. to 500°F. Lubricating ability, however, is not high, and the fluids are recommended only for light to moderate loads, as in clocks and instruments. A similar fluid containing suspended graphite is recommended for conveyor bearings and oven machinery at high temperatures.

New Heat-Conducting Glass

➤ No ice will form on automobile windshields the glass of which is heated by electricity passing through an invisible film coating. There is one catch, however. Higher voltage is necessary than found on the average family automobile.

The new windshield is a product of Libbey-Owens-Ford Glass Company and has been thoroughly tested during the past winter on several cars in all sorts of freezing rain and below-zero weather. The glass is heated by a continuous electric current which passes through the coating. The covering film is basically stannic oxide, which can be made from any number of tin compounds. Its slight coloring offers no noticeable decrease in visibility.

The recommended scheme to get sufficient voltage is to replace the conventional generator on the car with an alternating current generator. Its current can be transformed to voltages sufficiently high to perform the heating operation. Generators now used in cars for radio transmission can be used for the de-icing.

A new method for analyzing minute quantities of boron utilizes a reaction between boron and benzoin in an alcohol solution; microgram quantities of boron can be detected by green fluorescence in ultraviolet light.

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